Thinking About Thinking: Enhancing Creativity and Understanding in Operational Planners

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Abstract

THINKING ABOUT THINKING: ENHANCING CREATIVITY AND UNDERSTANDING IN OPERATIONAL PLANNERS by MAJ Thomas A. Kurtz, United States Army, 73 pages

Creativity, the generation of new ideas that are both novel and appropriate is essential to understanding complex problems, and can be enhanced by both life experience diversity and cognitive diversity, as well as by delayed evaluation during problem solving, or can be inhibited by a lack of diversity and cognitive entrenchment. In essence, creativity is dependent on associating a wide array of novel or divergent experiences to form a new, appropriate, idea, however closed institutions such as the U.S. Army have limited pools of divergence from which to draw, relying instead on the commanders experience, which may provide exposure to many ideas over a lengthy career, but the ability to associate them into new creative ideas may be inhibited over the same time period. The same skills that allow a commander to be successful while solving routine or simple problems may actually inhibit his ability to solve complex or ill-structured problems. The importance of enhancing creativity is to balance the concrete specialized experiences, education, and intuitions developed in successful leaders with more abstract and diverse creativity in order to promote better understanding.

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Introduction

Introduction: The Importance of Enhancing Creativity

Joint Publication 5-0, Joint Operation Planning, describes understanding as summative of a commander's "experience, intellect, creativity, intuition, education, and judgment."[1] Army Field Manual 5-0, The Operations Process, defines Army design methodology as:

> A methodology for applying critical and creative thinking to understand, visualize, and describe complex, ill-structured problems and develop approaches to solve them. Critical thinking captures the reflective and continuous learning essential to design. Creative thinking involves thinking in new, innovative ways while capitalizing on imagination, insight, and novel ideas.[2]

Each of these primary operations manuals lists creativity as a key component to understanding, and without interpretation, creativity is the only common element that facilitates understanding according to each manual's description. If creativity is the link to understanding, especially complex and ill-structured problems, then its importance to commanders and operational planners seems apparent. Another fascinating discussion point identified by the descriptions of understanding provided in FM 5-0 and JP 5-0 is the relationship between critical and creative thinking. If critical thinking is dependent on experience and education, and creative thinking involves new, insightful, novel, and innovative ways of thinking, then can the two types of thinking be equally represented in one person or group? Alternatively, if one type of thinking becomes dominate, then does it do so at the detriment of the other? Specifically, if creativity is the key element to understanding, can an over reliance on critical thinking hinder creativity and potentially prevent understanding? Developing an understanding of creativity raises three primary questions: What is creativity, how does creativity happen, and can creativity be enhanced or

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[1]U.S. Department of Defense, Joint Publication 5-0, Joint Operation Planning (Washington, DC: Headquarters, Department of the Army, October 2008), 3-2.

[2]U.S. Department of Army, Field Manual 5-0, The Operations Process, Change 1 (Washington, DC: Headquarters, Department of the Army, March 18, 2011), 3-1.

inhibited? What is creativity? A most basic definition of creativity is the generation of an idea that is both novel and appropriate. Novel in that it creates new and unexpected associations from preexisting knowledge, and appropriate in that it has some value to the person or system. How does creativity happen? The most basic theory describes creativity as a four-step process involving: preparation relearning and thinking about a problem; incubation - removing the problem from conscious thought; illumination - a moment of insight when the novel thought occurs; and verification – assessing its appropriateness.[3] Army FM 5-0 describes the operations process as an iterative cycle of understanding, visualizing, describing, and directing.[4]
The U.S. Army is inherently an institution of action, and situational understanding, problem identification, and problem solutions are intrinsically interconnected in operational planning. For operational planners, creativity is critical to understanding, which may assist identifying the "correct" problem and developing problem solutions. When planning against complex and ill-structured problems, understanding, identification, or problem solution is not a simple regurgitation of already known ideas. Creative understanding, problem identification, and solutions are new and unexpected – they are created.

Overlaying a basic creativity model on the operations process shows that illumination, or that moment of insight, is actually the catalyst that moves the process from understanding to visualization and description. Because critical problem solving does not provide easily identifiable, probable solutions for complex problems, creativity is significantly important to commanders and planners when they face complex, ill-structured problems. In this way, creativity can produce an entirely new set of possible solutions that could not have been produced through critical thinking alone.

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[3]Graham Wallas, *The Art of Thought* (London: J. Cape 1926): 26-80.

[4] U.S. Department of the Army, Field Manual 5-0, 5-3.

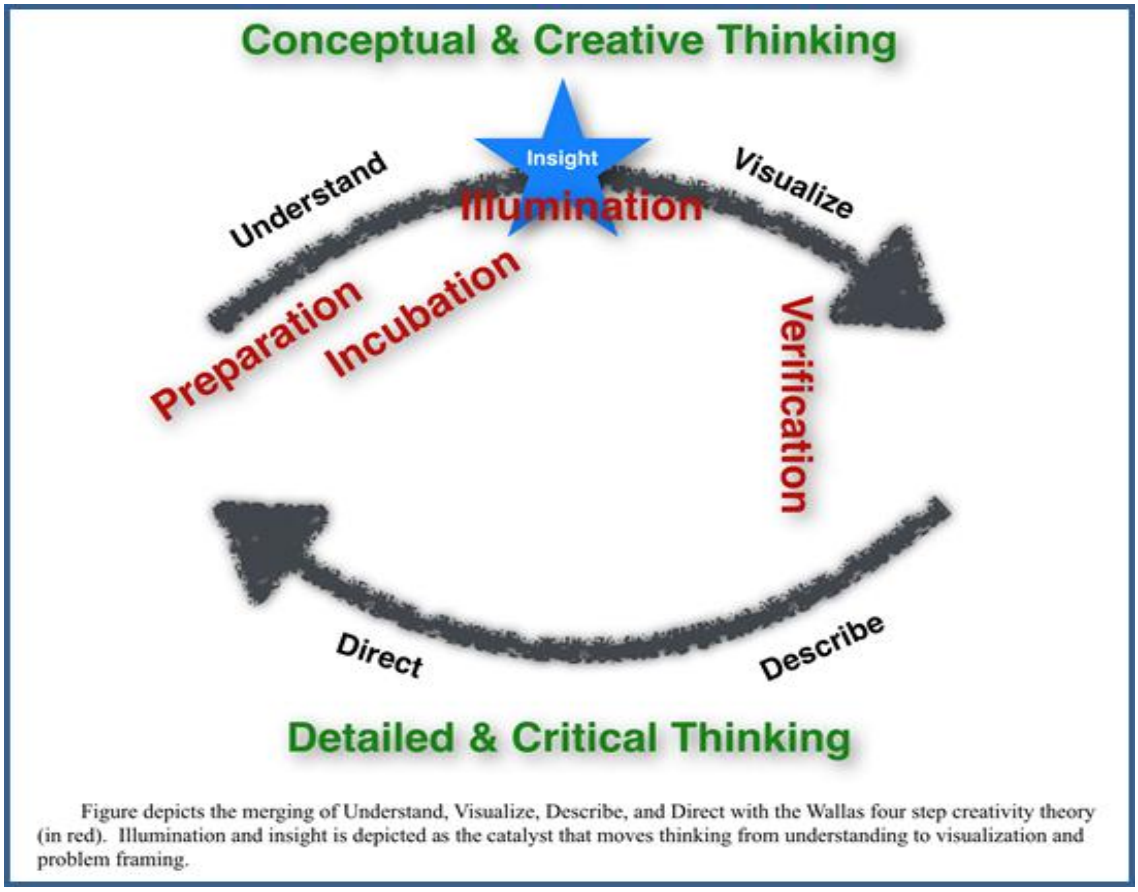

Figure 1: U.S. Army Operations Process Combined with Wallas Four-Step Theory[5]

To state it another way, creativity is key to understanding complex environments when understanding requires the introduction of new ideas into the thought process. Critical thinking alone does not introduce new ideas, but it can rearrange an infinite number of preexisting ideas, not introduce anything new, and result in the same solution each time. For example, if A, B, C, D are preexisting ideas that provide understanding (U), no matter how you rearrange the variables, you still get the same result, A+B+C+D=U. This is not to argue that critical thinking is simple or

[5]T. Kurtz, Figure 1 depicts how the U.S. Army operations process of understand, visualize, describe and direct shares similarities with the Wallas classic four-step creativity theory. Understanding in the U.S. Army model aligns with Wallas phases of preparation and incubation, which fosters conceptual and creative thinking. Both concepts then rely on a moment of insight to move from conceptual understanding to visualization and subsequent problem framing, typically associated with detailed and critical thinking.

easy; but, if you don't know what A, B, C, or D are, then solving for U is extremely difficult. However, given enough modeling effort and thought, critical thinking alone can solve for U. If U does not provide understanding, then a new idea needs to be created and introduced, the variable Z for example. Z is not in the original understanding formula, it was a product of creativity and provides a new understanding, A+B+C+D+Z=U1.

How can creativity be enhanced or limited? There are many creativity-enhancing factors, two essential creativity precursors and enhancers are diversity enhance life experience diversity and cognitive diversity - and avoiding early evaluation during problem solving. There are also many creativity-inhibiting factors, of which two primary creativity inhibitors include limited exposure to new and novel ideas or new problem solving examples, and cognitive entrenchment. It seems clearly visible that creativity enhancers and inhibitors are directly opposite in their nature and tendencies; the greater the diversity, the greater the creativity, the more limited the diversity, the more limited the creativity. The same can be stated for avoiding early evaluation during problem solving as opposed to quickly determining problem solutions based on cognitive entrenchment.

Why is it important for commanders and planners to enhance creativity? The same skills that allow a commander to be successful while solving simple or complicated problems may actually inhibit his ability to solve complex or ill-structured problems. Professional success is usually associated with years of specialized narrowly focused experience, specialized and focused education, and entrenched intuitions, that when combined allow for rapid problem solution identification. However, complex and ill-defined problems requiring creative solutions may need additional time, multiple diverse inputs, as well as suspension of early solution finding before a problem solution emerges. Creative problem solving, essentially the polar opposite of critical problem solving, can be a very uncomfortable process for a successful professional accustomed to rapid problem solution identification. The importance of enhancing creativity is to balance the

concrete specialized experiences, education, and intuitions developed in successful leaders with more abstract and diverse creativity.

The primary argument of this paper is based on the logic that creativity, the generation of new ideas that are both novel and appropriate, is essential to understanding complex problems. Additionally, creativity can be enhanced by both life experience diversity and cognitive diversity, as well as by delayed evaluation during problem solving, or can be inhibited by a lack of diversity and cognitive entrenchment. In essence, creativity is dependent on associating a wide array of novel or divergent experiences to form a new, appropriate idea; however, closed institutions such as the U.S. Army have limited pools of divergence from which to draw, relying instead on the commander's experience, which may provide exposure to many ideas over a lengthy career, but the ability to associate them into new creative ideas may be inhibited over the same time period.

The argument forwarded in this paper is supported by research-based, theoretical, and practical evidence in three sections: Creativity Defined, The Science of Creativity, and Creativity Enhancers and Inhibitors. The first section of this monograph defines creativity by examining what creativity is, how it happens, theories associated with the creativity process, and concludes with an exploration of the three core steps of creativity – conceptual integration, insight, and emergence. Section two, relies on neuroscience and cognitive psychology to examine the cognitive science that provides understanding of how and why creativity happens. The importance of this section is that it provides an evidence based link between the definition of creativity, which is somewhat abstract and void of concrete examples, and the specific creativity enhancers and inhibitors proposed in section three.

Creativity Defined: Novel and Valued Ideas

What is Creativity: Generation of New Ideas by Ordinary Mental Processes

Creativity in humans is a complex behavior involving utility, beauty, and innovation.[6] The creative process, a sequence of thoughts and actions leading to a novel, adaptive, useful idea has been one of the key topics of creativity research during the past century.[7] Research on insightful problem solving, creative cognition, and expertise acquisition, in addition to traditional historic case studies of exceptionally creative individuals, has replaced the belief that creativity is a mysterious or even mystical event.[8]

Creativity is in fact grounded in ordinary mental processes.[9] Creative cognition science provides an understanding of creativity by focusing on the cognitive processes and activities that underlie the production of creative ideas such as memory retrieval, visualization, categorization, problem solving, and analogical transfer.[10] Creative cognition science currently asserts that novel and creative ideas emerge from the application of ordinary, fundamental cognitive processes that

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[6]Rosalind Arden, Robert S. Chavez, Rachael Grazioplene, and Rex E. Jung, "Neuroimaging Creativity: A Psychometric View," Behavioral Brain Research, Volume 214, Issue 2 (December 2010): 144; D.K. Simonton, "Talent and Its Development: An Energenic and Epigenetic Model," Psychological Review, Volume106, Issue 3 (July 1999): 436.

[7]Todd I. Lubart, "Models of the Creative Process: Past, Present and Future," Creativity Research Journal, Volume 13, Issue 3 (October 2001): 295.

[8] Keith Simonton, "Creativity," American Psychologist Volume 55, Issue 1 (January 2000): 151.

[9]Margaret A. Boden, "Creativity and Artificial Intelligence," Artificial Intelligence Volume 103, Issue 1 (August 1998): 347; Thomas B. Ward, S. M. Smith , and R. A. Finke, "Creative Cognition," in Handbook of Creativity., ed. R. J. Sternberg (Cambridge: Cambridge University Press, 1999) 189-212; Arne Dietrich, "The Cognitive Neuroscience of Creativity," Psychonomic Bulletin and Review, Volume 11, Issue 6, (Austin: December 2004): 1012.

[10]Andruid Kerne, Steven M. Smith, Eunyee Koh, Hyun Choi, and Ross Graeber, "An Experimental Method for Measuring the Emergence of New Ideas in Information Discovery," International Journal of Human-Computer Interaction Volume 24, Issue 5 (June 2008): 462.

combine previously disassociated existing knowledge into new ideas.[11] The mental process that finally results in a creative idea's formation starts with novel and divergent thinking.

Novel and Divergent Thinking: Catalysts of Creativity

Novel and divergent thinking is often defined as a new configuration of mental elements - the processing of remote or loose associations between ideas, none of which are individually novel - which produces some new pattern of relatedness.[12]

To investigate novel and divergent thinking, researchers in this area design divergent thinking studies in which subjects produce as many answers possible to open-ended questions without regard to applicability or usefulness.[13] A major shortcoming of divergent thinking tests is that divergent thinking is too broad of a construct to provide a precise characterization of the creative processes.[14] In one sense, novel and divergent thinking are practically a definition of creativity - new patterns of relatedness resulting in unpredictable combinations. However, this only relates novelty to quantity of combinations, not the quality or usefulness of the combinations. Although novel and divergent thinking are critical creativity precursors that either inhibit or enhance creativity, depending on how limited or expansive the knowledge and experience base is from which they are conceived, they are not creativity by themselves. Novel or

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[11] Thomas B. Ward, "Creative Cognition as a Window on Creativity," Methods Volume 42, Issue 1 (May 2007): 28.

[12] R. K. Sawyer, "The Emergence of Creativity," *Philosophical Psychology* Volume 12, Issue 4 (December 1999): 448, 460.

[13] R. A. Finke, "Imagery, Creativity, and Emergent Structure," *Consciousness and Cognition* Volume 5, Issue 3 (September 1996): 383; Jami J.Shah, Steven M. Smith, and Noe Vargas-Hernandez, "Metrics for Measuring Ideation Effectiveness," *Design Studies* Volume 24, Issue 2 (March 2003): 161; Kerne, S. Smith, Koh, Choi, and Graeber, "An Experimental Method for Measuring the Emergence of New Ideas," 464.

[14] T. Ward, "Creative Cognition as a Window on Creativity," 29.

divergent thinking is not sufficient for creativity; in addition, the new creation must somehow be viewed as useful, appropriate, or valuable to some system.[15]

Appropriateness and usefulness require an exploration of how different systems require, accept, and reward different degrees of novelty or divergence. Most creativity theories and models describe a relationship between novelty and divergent thoughts and the higher order mental processes that judge the appropriateness and value of the novel thought. A novel reconfiguration lacking appropriateness or value most likely will never emerge into system consciousness as a new thought. Failing to pass some type of appropriateness filter, it will be recycled back into the pool of subconscious or subsystem knowledge.[16] Creativity can be thought of as a continuous process of generating novel or divergent thoughts and assessing their usefulness or value to a situation or system.

Creativity is the generation of the new novel or divergent ideas from existing knowledge by the application of basic cognitive processes and assessed as appropriate and valued.[17] Creativity researchers have reached a consensus that creativity is characterized by two essential properties, first, it is original, novel, and unexpected in some way; and second, it is useful, practical, or in some way appropriate to some domain or system of criteria.[18] Another way to explain the creativity process is as a series of divergent and convergent activities.[19]

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[15]Sawyer, "The Emergence of Creativity," 456.

[16]Sawyer, "The Emergence of Creativity," 459.

[17]T. Ward, "Creative Cognition as a Window on Creativity," 28.

[18]Sawyer, "The Emergence of Creativity," 448; T. Ward, "Creative Cognition as a Window on Creativity," 28; Kerne, S. Smith, Koh, Choi, and Graeber, "An Experimental Method for Measuring the Emergence," 462.

[19]Arthur J. Cropley, "Defining and Measuring Creativity: Are Creativity Tests Worth Using?" *Roeper Review* Volume 23, Issue 2 (December 2000): 72.

Creativity: Divergent Catalysts meet Convergent Value

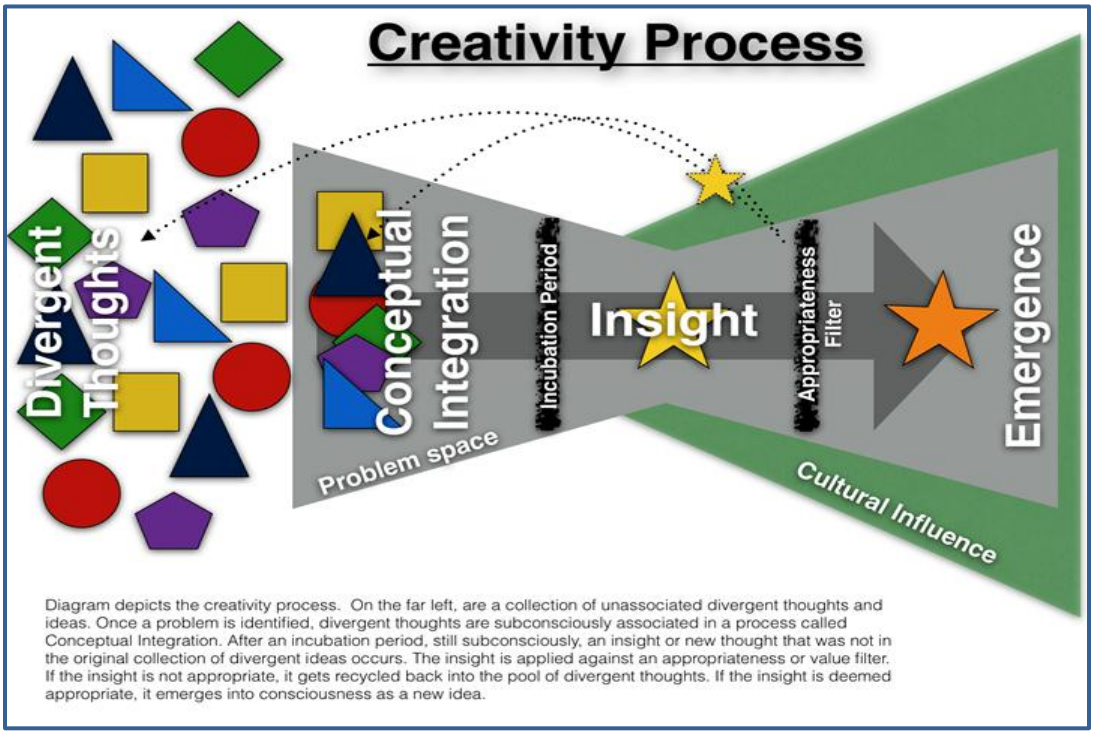

Figure 2: The Creativity Process[20]

New and novel ideas develop during the divergent phase; and are combined and assessed for value during the convergent phase. Creativity not only depends on the cognitive process of novel or divergent thinking to merge previously unconnected ideas or thoughts, but also on social influenced convergent thinking as well which serves as an appropriateness or value filter,

[20]T. Kurtz, Depiction of the creativity process. On the far left, are a collection of unassociated divergent thoughts and ideas. Once a problem is identified, divergent thoughts are subconsciously associated in a process called conceptual integration. After an incubation period, still subconsciously, an insight or new thought that was not in the original collection of divergent ideas occurs. The insight is applied against an appropriateness or value filter. If the insight is not appropriate, it gets recycled back into the pool of divergent thoughts. If the insight is deemed appropriate, it emerges into consciousness as a new idea.

ultimately resulting in a form of "sensemaking" and problem solving.[21] As mathematician Henri Poincare pointed out in 1913, creativity does not consist simply of making new combinations: "It is not merely a question of applying rules, of making the most combinations possible according to certain fixed laws. The combinations so obtained would be exceedingly numerous, useless and cumbersome. The true work of the inventor consists in choosing among these combinations so as to eliminate the useless ones."[22]

The appeal of adding convergence to the creativity process is that it forms a relationship between the disparate novel or divergent part of the creativity process and the final creative result. Convergent activity serves to bind potentially unrelated novel and divergent thoughts to produce an unexpected new whole, with valued and appropriate new properties, that could not have been fully anticipated given the uniqueness of the individual parts. Graham Wallas first theorized this process in 1926.[23] Years of creativity research have led to the evolution of Wallas' basic theory, as well as introduction of additional theories; however, no revolutionary theory explaining creativity has been introduced since.

Creativity Theories: From the Classic Four-Stage to Modern Systems Theory – Multistep Divergent and Convergent Processes

The following overview of several classic creativity theories shows consistent progression of understanding the creative process within the cognitive and creativity sciences. Each model, in its own way, is consistent with the previously proposed creativity definition and

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[21]Timothy C. Rickards and Alice F. Healy, "On the Cognitive Structure of Basic Arithmetic Skills: Operation, Order, and Symbol Transfer," *Journal of Experimental Psychology, Learning, Memory, and Cognition* Volume 20, Issue 5 (September 1994): 1143; Karl E. Weick, Kathleen M. Sutcliffe, and David Obstfeld, "Organizing and the Process of Sensemaking," *Organization Science* Volume 16, Issue 4 (July-August 2005):409.

[22]Harold C. Brown, "The Work of Henri Poincare," *The Journal of Philosophy, Psychology, and Scientific Method* Volume 11, Issue 9 (April 1914): 230; Sawyer, "The Emergence of Creativity," 448.

[23]Wallas, 320.

accounts for both the novel divergent thinking as well as the value based convergent thinking. Of note, many creativity theories are framed in terms of problem solving. Researchers broadly define the term "problem" as any task that an individual seeks to accomplish such as an artist attempting to express a feeling, a scientist seeking to understand a complex phenomenon, or a planner seeking to appreciate complex or complicated problems.[24]

Graham Wallas first introduced the classic four-stage creative process theory in 1926. He proposed the complete creative act involves four important steps, which he identified as: preparation, incubation, illumination, and verification.[25] Wallas went on to identify certain abilities that may enhance creativity, including a sensitivity to problems and problem identification, a capacity to fluently produce many ideas, the flexibility to change one's mental set, an ability to reorganize mental models or constructs, an ability to deal with complexity, and an ability to evaluate.[26] Wallas' theory, for the most part, has withstood 80 years of cognitive science and creativity research. Cognitive science has progressed and produced tremendous depth of understanding of each of the four steps; however, the four steps remain a valid construct for the creative process. The one caveat to the process is, as will be highlighted in the Treffinger theory below, that it is currently accepted that creativity is a non-linear process, unlike what Wallas and his peers seemingly presumed in 1929. It appears Wallas envisioned, and depicted, the creativity process as a system of fixed steps, with each leading to the next. Infusing a modern concept of nonlinearity into Wallas' classic theory allows it to continue as a valid creativity theory today.

The evolutionary theory of creativity is usually associated with DT Campbell who introduced it in 1960. He proposed that creativity was subject to the same three-stage process as

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[24]Todd I. Lubart, 297.

[25]Wallas, 26-80; Lubart, 295.

[26]Wallas, 97.

evolution: blind variation, selection, and retention.[27] This once prominent view of creativity described divergence as wide and frequent variation based on “trial and error and fluency of ideas”.[28] As well as the emergence and selection of the variation or idea, or what is currently defined as convergence.[29] Fifty years later, a novel insight is still often defined as a new configuration of mental elements – the processing of remote or loose associations between ideas, none of which are individually novel.[30] The evolutionary theory provided an explanation of cognitive discovery of new relationships among variables, therefore bettering the chance of "species" survival of the novel idea as it passes through the appropriate filter. In this regard, the evolutionary theory of creativity still represents a valid construct for explaining creativity as a series of divergent and convergent activities.

Csikszentmihalyi's influential systems theory of creativity, introduced in 1988, was derived from Campbell's evolutionary theory. Csikszentmihalyi explored three interconnected systemic components that work in unison to generate a creative product. In his theory, the creative individual generates a novel or divergent product; the field, a social system of individuals in a discipline, evaluates novel products in a convergent process and selects some of them according to established criteria; and a domain, an external body of work whose stable physical

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[27]Donald T. Campbell, “Blind Variation and Selective Retentions in Creative Thought As In Other,” *Psychological Review* Volume 67, Issue 6 (November 1960): 383; Keith Simonton, “Creativity as Blind Variation and Selective Retention: Is the Creative Process Darwinian?” *Psychological Review,* Volume 10, Issue 4 (October 1999): 310.

[28]Sawyer, “The Emergence of Creativity,” 448.

[29]Sarnoff Mednick, “The Associative Basis of the Creative Process,” *Psychological Review* Volume 69, Issue 3 (May 1962): 221; John Kounios and Mark Beeman, “The Aha! Moment: The Cognitive Neuroscience of Insight,” *Current Directions in Psychological Science* Volume18, Issue 4 (August 2009): 214.

[30]Sawyer, “The Emergence of Creativity,” 448.

traits allow it to serve the function of retention across time.[31] Csikzentmihalyi's creativity theory was the first to envision creativity as a holistic, interconnected process.

Simonton's cognitive theory, also introduced in 1988, proposed that individuals expand their cognitive domain by first internalizing "mental elements" such as facts, theories, and images and store them in the brain. Simonton further explained that during a subconscious creative process, the stored mental elements combine into chance divergent configurations, and although many of these novel configurations fail to pass an appropriate filter and make it into consciousness, some of them are "stable" enough to emerge and cause the subjective sensation of having an insight.[32]

Amabile's 1996 update to her 1983 componential theory of creativity continues her association with the Wallas classic four-stage theory. The componential theory described the creative process consisting of three primary components that combine to cause creativity. Amabile's components consist of problem or task identification, preparation by means of gathering or reactivating relevant information and resources, response generation by seeking and producing potential responses, and finally, response validation and communication in order to test possible responses against criteria.[33] What differentiates Amabile's theory from Wallas' is the formal inclusion of problem identification; although Wallas identified it as a creativity enhancer, he did not include it in his theory.

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[31]Giovanni B. Moneta and Mihaly Csikszentmihalyi, "Models of Concentration in Natural Environments: A Comparative Approach Based on Streams of Experiential Data," *Social Behavior and Personality: An International Journal* Volume 27, Issue 6 (December 1999): 604; Sawyer, "The Emergence of Creativity," 448.

[32]Simonton, "Creativity as Blind Variation and Selective Retention," 312; Sawyer, "The Emergence of Creativity," 449.

[33]Regina Conti, Heather Coon, and Teresa M. Amabile, "Evidence to Support the Componential Model of Creativity: Secondary Analyses of Three Studies," *Creativity Research Journal* Volume 9, Issue 4 (October 1996): 385; Todd I. Lubart, "Models of the Creative Process: Past, Present and Future," *Creativity Research Journal*, Volume 13, Issue 3 (October 2001): 297.

As mentioned in the discussion of the Wallas four-stage theory, Treffinger introduced his theory in 1995 that further removed creativity from a fixed sequence of activities as presented in the Wallas four-stage theory. Treffinger depicted three non-sequenced sets of interconnected processes labeled as understanding the problem, generating ideas, and planning for action. Understanding the problem includes the processes of mess finding and problem realization, data finding and preparation, and problem finding, which involves generating as many possible questions about the problem and then focusing the questions. Generating ideas includes idea finding and creating associations through divergent thinking, elaboration of ideas, and convergent thinking, which provides evaluation of the ideas. Planning for action concerns developing and implementing ideas through solution finding by evaluating, selecting, and refining options as well as acceptance finding by idea promotion, seeking support, and noting resistance.[34] The sequence of the three processes can vary depending on an individual's understanding of the problem, what and when ideas are generated, and how the plan for action is realized.[35] Additionally, both divergent and convergent thinking is embedded within each set of processes.

Common in all these theories, regardless of whether they were originally conceived as a fixed sequence or a more modern integrated, nonlinear systems process is, they all propose a multi-step creativity process involving divergence to create novelty, a value or appropriateness filter (either mental, social, or both), and convergence resulting in selection of a new idea.[36] These three core steps are commonly referred to as conceptual integration, insight, and emergence; collectively they are the cognitive process of creativity.

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[34]Donald J. Treffinger, "Creative Problem Solving: Overview and Educational Implications," *Educational Psychology Review* Volume 7, Issue 3 (September 1995): 306-8.

[35]Lubart, "Models of the Creative Process," 300.

[36]Sawyer, "The Emergence of Creativity," 449.

Conceptual Integration: Conceptual Blending, the Fundamental Stimulant of Creativity

In anecdotal accounts, the most commonly noted creative process is the combining or blending of previously separate elements such as words, concepts, visual forms. New ideas, insights, or discoveries, all containing novel properties that would not have been expected from the separate elements, emerge from the new combinations or blends. Whether in science, technology, art, music, literature, or other creative realms, cognitive combinations and blends are fundamental stimulants to creativity.[37] Although a range of processes may contribute to the generation of creative ideas,[38] some researchers suggest that a particular set of operations – "conceptual combination and reorganization" – often spurs creative idea generation.[39] Combining concepts has been essential to creativity theories that stem from creativity research. Multiple creativity studies have focused on problem solving, idea generation and insight experiences, describing how novel properties emerge from conceptual combinations.[40]

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[37] T. Ward, "Creative Cognition as a Window on Creativity," 34.

[38] D. Campbell, 383; Dietrich, "The Cognitive Neuroscience of Creativity," 1012; Sarnoff Mednick, "The Associative Basis of the Creative Process," 221; S. Smith, T. Ward, and R. Finke, *The Creative Cognition Approach*. (Cambridge, MA: MIT Press 1995), 192; G. Wallas, 451.

[39] Wayne A. Baughman and Michael D. Mumford, "Process-analytic Models of Creative Capacities: Operations Influencing the Combination-and-Reorganization Process," Creativity Research Journal Volume 8, Issue 1 (January 1995): 38; Michael D. Mumford, Wayne A. Baughman, Michelle A. Maher, David P. Costanza, and Elizabeth P. Supinski, "Process-based Measures of Creative Problem-Solving Skills: IV Category Combination," Creativity Research Journal Volume 10, Issue 1 (January 1997): 61; Ginamarie M. Scott, Devin C. Lonergan, and Michael D. Mumford, "Conceptual Combination: Alternative Knowledge Structures, Alternative Heuristics," Creativity Research Journal Volume 17, Issue 1 (January 2005): 82; Dane, "Reconsidering the Trade-Off Between Expertise and Flexibility," 587.

[40] Fintan J. Costello and Mark T. Keane, "Testing Two Theories of Conceptual Combination: Alignment versus Diagnosticity", *Journal of Experimental Psychology.Learning, Memory, and Cognition* Volume 27, Issue 1 (January 2001): 267; M. Mumford et al.,"Process-based Measures of Creative Problem-Solving Skills," 64; Kerne, S. Smith, Koh, Choi, and Graeber, "An Experimental Method for Measuring the Emergence of New Ideas," 462; Zachary Estes, and Thomas B. Ward, "The Emergence of Novel Attributes in Concept Modification," *Creativity Research Journal* Volume 14, Issue 2 (April 2002): 149; Merryl J. Wilkenfeld and Thomas B. Ward, "Similarity and Emergence in Conceptual Combination," *Journal of Memory and Language* Volume 45, Issue 1 (July 2001): 150.

Conceptual integration describes the mental blending or combining of two unassociated ideas or concepts in the thinker's mind.[41] In 1993, Gilles Fauconnier and Mark Taylor coined the phrase "conceptual blending" as the basic mental operation that leads to new ideation, insight, and meaning.[42] Fundamental to blending is the arrangement of partial matches between two discrete inputs, "to project selectively from those inputs into a novel 'blended' mental space, which then dynamically develops emergent structure."[43]

Later, in 1998, Fauconnier and Taylor described the blending process as a three-step operation consisting of: composition or the arrangement of divergent or discrete inputs; completion, the subconscious binding or insightful convergence of the composition into a meaningful idea the moment of insight; and finally, elaboration as the idea emerges through the appropriateness filter. During conceptual blending, thoughts move between "mental spaces" that form ideas according to such elements as points of view, presuppositions, beliefs, past experiences analogies, metaphors, and such. Conceptual blending potentially results in an emergent creative idea not present in the original input mental spaces or predictable from the inputs alone.[44]

It is important to note, concerning conceptual integration, that as discussed in Simonton's cognitive theory, creative individuals typically internalize vast and varied data inputs from diverse arrays of experience, socialization, training, and education. From this preparation phase, common, non-novel thoughts are integrated into new, novel, and creative combinations. It seems

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[41]Thomas B. Ward, "Creative Cognition as a Window on Creativity," *Methods* Volume 42, Issue 1 (May 2007): 34.

[42]Mark Turner and Gilles Fauconnier, "Conceptual Integration and Formal Expression," *Metaphor and Symbolic Activity* Volume 10, Issue 3 (September 1995): 185.

[43]Ibid., 184.

[44]Jeffery Goldstein, "Creativity, and the Logic of Following and Negating," *The Innovation Journal* Volume 10, Issue 3 (May 2005): 3.

very unlikely that human creativity could occur without wide-ranging and diverse raw material with which to work.

Although a wide array of diverse experience seems essential from which conceptual integration can be inspired, there are cautionary notes regarding conceptual integration and the resulting creative output. Research suggests that "routine" creative ideas are often the result of blending highly specific examples of past solutions to current problems. This tendency, although possibly facilitating rapid creative solution development, also imposes the liabilities and constraints of the highly specific solutions onto the new solutions. Researchers have studied the apparent value and appropriateness of creative abstract concepts versus more routine and familiar concepts that relied on known specific examples. During the creation of a new tool, subjects who reported reliance on specific, known examples produced creations that were rated as less original; however, their creations were also rated higher on the extent to which people would actually want to use them.[45] An approach of using specific examples during routine creative generation may favor practicality, time management, and familiarity, and possibly result in a product that is more accessible and generally more accepted when compared to the often apparently impractical, unfamiliar, difficult, and abstract extraordinary creation.[46] Reliance on known, highly accessible examples may limit the originality component of creativity, but enhance the practicality component.[47]

What is now accepted within the creative research community is that cognitive integration follows a sequence, whether as depicted by Fauconnier and Taylor, or Simonton or any of the other creativity theorists – routine or abstract mental constructions are developed by

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[45]T. Ward, M. J. Patterson, C. Sifonis, R. A. Dodds, and K. N. Saunders, "The Role of Graded Structure in Imaginative Thought," *Memory and Cognition* Volume 30 (2002): 205.

[46]T. Ward, "Creative Cognition as a Window on Creativity," *Methods* Volume 42, Issue 1 (May 2007): 30.

[47]Ibid., 33.

combining or blending at least two previously unrelated thoughts or experiences through the process of cognitive integration. After conceptual integration, the next step in the creative process is the integrated thoughts form an insight, which can lead to the emergence of new ideas or thoughts.[48]

Insight: The "A-ha!" Moment that Bridges Divergence to Convergence

Insight is the moment or experience that bridges cognitively integrated divergent or novel concepts to the convergence and emergence of creative thoughts. Insight is the initial step of convergence as well as the first step towards generating a creative new thought. Insight can be defined as that "A-ha!" moment when diverse thoughts integrate to form an idea – a conceptual reorganization that results in a new, non-obvious creative thought. Insight during problem solving is often experienced during a down-regulated or diffused attention moments, or subsequent to a frustrated problem-solving attempt during an incubation period when the mind has focused elsewhere. During the moment of insight, problem related content comes to mind with sudden ease and provides a feeling of pleasure, the belief that the solution is true and confidence in this belief.[49] John Kounios and Mark Beeman state that insight, similar to creativity, is a new interpretation of a situation that can point to the solution of a problem; insights are often the result of reorganizing or restructuring the elements of a situation.[50]

All the previously reviewed creativity theories identify a moment of insight, although termed differently in each. The Wallas four stage theory describes a moment of illumination, Campbell's evolutionary theory refers to a selection stage, Simonton's cognitive theory describes

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[48]Goldstein, "Emergence, Creativity, and the Logic of Following and Negating," 4.

[49]Sascha Topolinski and Rolf Reber, "Gaining Insight Into the ''Aha'' Experience," *Current Directions in Psychological Science* Volume 19, Issue 6 (December 2011): 402.

[50]Kounios and Beeman, "The Aha moment!,"210.

a subconscious chance configuring of elements, Amabile's componential theory lists a response generation phase, and Treffinger describes one of his three sets as idea generation. Insight literature currently describes four primary characteristics of an insight experience. One, suddenness, the problem solution pops into mind abruptly and surprisingly.[51] Two, ease, regardless of how difficult the problem related processing might have been before, after the moment of insight problem processing progresses quickly and easily. Three, positive effect, an insight yields a genuine positive affective experience;[52] this positive affect comes before the assessment of the solution and therefore is not a conscious feeling of pride.[53] Four, truth and confidence, after an insight, problem solvers judge the solution as true and express confidence in that judgment, even before systematically assessing the solution's correctness or accuracy.[54]

Creative insights can arise either spontaneously or deliberately. In contrast to a deliberate creativity process, which is thought to be initiated by a focused prefrontal brain lobe database search, and limited to preconceived mental models or constructs, spontaneous creative insights are thought to be almost the opposite and tend to happen in unregulated, unfocused cognitive moments.[55] A number of researchers note spontaneous creative insights tend to occur in what is characterized as a defocused or diffused attentional state.[56] In the moments when the attentional system is defocused, thoughts, unguided by societal norms and unfiltered by conventional

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[51]M. Gick and R. Lockhart, "Cognitive and Affective Components of Insight," in *The Nature of Insight*, eds. R. J. Sternberg, J. Davidson, (Cambridge, MA: MIT Press 1995): 200.

[52]H. E. Gruber, "Insight and Affect in the History of Science," in *The Nature of Insight*, eds. R. J. Sternberg, J. Davidson (Cambridge, MA: MIT Press 1995): 399.

[53]Topolinski, Reber, "Gaining Insight Into the ''Aha'' Experience," 402.

[54]Gick and Lockhart, "Cognitive and Affective Components of Insight," 202; Topolinski, Reber, "Gaining Insight Into the ''Aha'' Experience," 402.

[55]Dietrich, "The Cognitive Neuroscience of Creativity," 1016.

[56]Hans J.Eysenck, "Creativity and Personality: Suggestions for a Theory," *Psychological Inquiry* Volumer 4, Issue 3 (July 1993): 163; Dietrich, "The Cognitive Neuroscience of Creativity," 1015.

rationality, become represented in working memory.[57] In this defocused and diffused attentional state, conscious thinking is characterized by unsystematic drifting, and the sequence of thoughts manifesting itself in consciousness are more chaotic, permitting more "loosely connected" associations to emerge.[58] As stated earlier, Fauconnier and Taylor described this as their "mapping process"; thoughts moving unrestrictedly through the many areas of the brain, ultimately collecting in a novel "blended space," the joining of many divergent thoughts in a moment of insight.

An anecdotal example of insight comes from Hermann von Helmholtz, a physicist and physiologist working in the later part of the 19th century. He described how after investigating a problem thoroughly, while relaxing during a walk, "….happy ideas came unexpectedly without effort, like an inspiration."[59] Insight did not occur while Helmholtz deliberately focused his attention during critical thinking, thus limiting his possibility of divergent connections and the potential for insight, but rather, when he defocused his attention and allowed unconstrained novel connections to occur.[60] Dr. Helmholtz's moment of insight lead to the emergence of creative thoughts into his conscious mind, the third step of the creative process.

Emergence: Conscious Awareness and Potential Action

Emergence is the final of the three core creativity steps. Emergence is exciting because it is the awareness of the creative new thought and may promote better understanding and new problem solutions Emergence is the result of conceptual integration of divergent and novel

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[57]Arne Dietrich, "Functional Neuroanatomy of Altered States of Consciousness," *Consciousness and Cognition* Volume 12, Issue 2 (June 2003): 243.

[58]Dietrich, "The Cognitive Neuroscience of Creativity," 1016.

[59]Wallas, 80.

[60]Dietrich, "Functional Neuroanatomy ," 243; Wallas, 82; Lubart, "Models of the Creative Process," 295.

thoughts and experiences that lead to moments of insight and the formation of creative thoughts. Emergence represents action as the new thought flows into a person's consciousness after it passes through an appropriateness or value barrier. Emergence begins the first conscious steps by a person to understand, assess, and relate the new creative thought to a problem. It is associated with the positive effect of insight, or as Dr. Helmholtz described, those "happy inspirational ideas."

Creativity studies have begun using the term "emergent" to describe the process of how creative thoughts, ideas, and images can unexpectedly arise, radically distinct from whatever original inputs from which they were created.[61] In the course of creative ideation, novel ideas often emerge from blended or merged divergent ideas.[62] Even if the conceptually integrated elements are not novel in their own right, important creative discoveries in science, art, and business emerge from these novel combinations.[63]

The concept of emergence, just as insight, is present in all of the previously reviewed creativity theories in terms like verification, retention, stable thoughts emerging into conscious, response validation, and solution finding. What all of these theories are describing is the first conscious awareness and assessment of a creative thought. The assessment may primarily be mental as described by Simonton, or primarily social as Csikszentmihalyi describes, but it is more likely both. Ultimately, *emergence is an interaction between the known and accepted and the new and novel.*

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[61]Goldstein, "Emergence, Creativity, and the Logic of Following and Negating," 3.

[62]Kerne, S. Smith, Koh, Choi, and Graeber, "An Experimental Method for Measuring the Emergence of New Ideas," 463.

[63]Goldstein, "Emergence, Creativity, and the Logic of Following and Negating," 3.

By definition, cognitive emergence occurs in consciousness.[64] The concept assumes the existence of a cognitive agent capable of recognizing the awareness of a new novel thought, and be able to interpret, compare and assess the event based on what he or she currently knows and accepts.[65] Careful consideration of emergence requires an appreciation that emergence of new and creative ideas may be more appropriately described as constructed, dependent on social and cultural constraints rather than materializing independent of the same. These social and cultural constraints, along with an individual's own constraints such as experiences, preconceptions, and biases, construct the appropriateness or value filter an insight must pass through in order to emerge.

There are multiple viewpoints regarding the impact of societal and cultural bounds on conceptual integration and insight; however, culture and society probably affect the emergence and incorporation of new ideas. Coordination can be defined as 'the act of managing interdependencies between activities to achieve a goal.'[66] If an emergent idea can be more described as a constructed coordination process between the interdependent culturally accepted and the new emerged idea, then upon emergence the new creative idea is immediately injected into the cyclical process of creation. It now becomes another possibly diverse data point to be used during the next cycle of conceptual blending. In other words, the newly emerged idea is examined against the problem, if it provides a path towards progression, it is retained and socialized, or if not it is recycled back into the creative process as an additional divergent thought.

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[64]Dietrich, "The Cognitive Neuroscience of Creativity," 1011.

[65]Katerina Aiou, "Coordination and Emergence in Design," *CoDesign* Volume 6, Issue 2 (June 2010): 75.

[66]T. Malone and K. Crowston, "What is Coordination Theory and How Can It Help Design Cooperative Work Systems," Paper presented at Proceedings of the 1990 ACM Conference on Computer-Supported Work Systems, 361; Katerina Alexiou, "Coordination and Emergence in Design," *CoDesign* Volume 6, Issue 2 (June 2010): 77.

Multi-agent systems in particular provide explicit examples of emergence as a coordination event. In a multi-agent system, emergence is a process of generating new ideas ‘from the bottom-up', i.e. from one individual to a group. The dynamic of a multi-agent system means there is immediate interaction between the idea and the other individuals in the group. Whether the creative idea is verified, retained, validated, and added to the solution findings during socialization is dependent on the 'top-down' cultural assessment of the idea. Campbell, in his evolutionary model of creativity describes one reason that descriptions of emergence focused solely on the individual are incomplete, they do not account for downward causation, cultural or societal influence.[67] During downward causation, higher-level cultural or societal norms cause effect on the lower-level individual, influencing the interaction patterns of all the agents.

Although research has been successful at describing how individual bottom-up processes leads to creativity, Campbell and others advocate emergence is a shared understanding of the new creative idea and this understanding is an emergent social product. Creative idea emergence is reliant on social or cultural acceptance, yet once accepted it constrains and influences other emergent ideas.[68]

Section Summary: Creativity, Valued Novelty Generated by Divergent and Convergent Thinking

Creativity is the generation of new novel or divergent ideas from existing knowledge by the application of basic cognitive processes and is assessed as appropriate and valued.[69] Creativity researchers have reached consensus that creativity is characterized by two essential properties: first, it is original, novel, and unexpected in some way; and second, it is useful,

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[67]Simonton, “Creativity as Blind Variation and Selective Retention,” 311.

[68]Sawyer, “The Emergence of Creativity,” 453.

[69]T. Ward, “Creative Cognition as a Window on Creativity,” 28.

practical or in some way appropriateto some domain or system of criteria.[70] The three core steps of the creative process are conceptual integration, the blending and combining of previously unassociated ideas; insight, that A-ha! feeling, or the moment of illumination; finally emergence, when the insightful, new creative idea comes into consciousness. The creative process is about generating new ideas essential to understanding ill-defined and complex problems. *Creativity is the key component to introducing new ideas into the thought process, expanding understanding, and generating new problem solutions*. The U.S. Army operations process, as outlined in FM 5-0, parallels the creativity process. During the creativity process, preparation and incubation are antecedents of illumination and insight. Understanding is the forerunner to insight and visualization during the U.S. Army operations process. Key to both is understanding, and essential to understanding is creativity. The following section will further investigate creativity from a neurological perspective the connection between understanding what creativity is, and how it can be enhanced or inhibited

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[70]S. Smith, T. Ward, and R. Finke, 192; Kerne, S. Smith, Koh, Hyun, and Graeber, "An Experimental Method for Measuring the Emergence of New Ideas," 462.

Science of Creativity: Bridging Understanding Creativity to Practicing Creativity

The science of creativity bridges understanding a definition of creativity to potential creativity enhancers and limiters. Through understanding the science of creativity, a foundation can be established to support an evidence-based discussion of creativity enhancers and limiters that may run contrary to American military culture and western professional culture. Without understanding the science, the core steps of creativity – conceptual integration, insight, and emergence – might seem abstract and unattached from practicing creativity. The intent here is not to review all the evidence, but rather to provide a representation of the known science of creativity. In all the works read for this monograph, no creativity researcher claims that a single study, scale, test, battery, or construct defines the creative process entirely, but rather they argue the causes of creative cognition are multiple and some are better understood at the neurological level than others are.

This exploration of the science of creativity will first investigate conceptual integration, then move to insight, and finally examine emergence of creative ideas. Presented here is a limited selection of the vast body of peer-reviewed and published creativity evidence base. The first study presented is an anthropologic overview of neural activity that may lead to conceptual integration and potential creativity. It also introduces the interaction of left and right brain hemisphere activity during creativity. Presented next are two neurological research studies which provide greater detail of brain activity during conceptual integration and moments of insight, including increased activity in the section of right frontal brain associated with conceptual integration and insight, as well as decreased activity of the visual cortex section of the brain as the brain limits visual input during moments of abstract thought. The final study suggests evidence of the prefrontal cortex brain section providing the required value assessment of a novel insight prior to it emerging into consciousness as a creative thought.

Dr. Arthur Saniotis, an anthropology researcher, stated humans attempt to create and maintain order and a semblance of control in their environment by uniting novel or divergent elements and events into a unified whole.[71] To do this, the human brain, according to the concept of deep structure and the brains physical binary structure, naturally orders the world into oppositional or "binary" categories i.e. male/female, hot/cold, up/down, left/right.[72] This desire to create order, or aggregate dissimilar events, is a natural cognitive response to novelty.[73] As an example, Saniotis uses Victor Turner's Theory of Ritual as a model to explain attempts to create cognitive balance and order from periods of imbalance and disorder.

Turner divided ritual into three phases: separation, limen, and re-aggregation. The limen phase, the threshold of a physiological or psychological response, is the most significant to creativity, since during this phase, ritual participants experience transitional "liminality" – a state "betwixt and between" social norms and categorizations.[74] Turner and others contend the indeterminate cognitive properties of liminality foster new ways of mental exploration and contribute to novel and new associations of previously disassociated thoughts and ideas.[75] The spontaneous conceptual integration experienced during liminality is rooted in the interaction

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[71]C.D. Laughlin, Jr., J. McManus, and E. d'Quilli, "Introduction," in *The Spectrum of Ritual: A Biogenetic Structural Analysis* (New York: Columbia University Press 1979) 10; Arthur Saniotis, "Evolving Brain: Neuroanthropology, Emergence, and Cognitive Frontiers," *NeuroQuantology* Volume 7, Issue 3 (September 2009): 485.

[72]Peter K. Manning, "Lévi-strauss: 'Structural Anthropology,'" *Contemporary Sociology* Volume 7, Issue 2 1978: 141.

[73]Saniotis, 485.

[74]P. H. Gulliver, "Victor W. Turner: The Ritual Process: Structure and Anti-Structure (The Lewis Henry Morgan Lectures, 1966) London: Routledge and Kegan Paul, 1969. *Bulletin of the School of Oriental and African Studies* Volume 34, Issue 1: 195; M. Deflem, "Ritual, Anti-Structure, and Religion: A Discussion of Victor Turner's Processual Symbolic Analysis," *Journal for the Scientific Study of Religion*, Volume 30, Issue 1 (March 1991):12.

[75]Saniotis, 485; Simonton, "Creativity as Blind Variation and Selective Retention," 312.

between the brain's left and right hemispheres and their corresponding ergotropic and trophotropic activities.[76]

The central and peripheral nervous systems work in conjunction to control the body. The peripheral nervous system contains the sympathetic nervous system (SNS), and the Parasympathetic nervous system (PNS). The interaction of the SNS and PNS within the peripheral nervous system is exceptionally complex, as is the interaction between the peripheral and central nervous systems. However, explained in oversimplified terms, the SNS is connected to the adrenal glands and the amygdala brain sections and its interaction is called ergotropic (Greek: ergo = to work) and is associated with arousal and fight or flight. The SNS arouses the left-brain hemisphere. The PNS connects to the endocrine glands, thalamus, and hypothalamus brain sections, and its interaction is termed trophotropic. (Greek: trophos = to nourish) and is associated with rest.[77] The PNS arouses the brains right hemisphere. The arousal of the left hemisphere ergotropic (work) system during ritual behavior excites the right hemisphere trophotropic (nourish) system, leading to "hyperarousal and hyperquiescent states,"[78] or arousal of both the "feeling and reacting" portions or the brain. The switching back and forth between the two systems often triggers altered or non-ordinary states of consciousness.[79]

Studies of the brain hemispheric relationships suggest that rhythmic and repetitive movements such as dancing, clapping, and body swaying engage the lower cognitive functions of the right, "working" hemisphere, whereas repetitive chanting such as Hindu and Buddhist mantra

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[76]Saniotis, 485; M. Deflem, "Ritual, Anti-Structure, and Religion: A Discussion of Victor Turner's Processual Symbolic Analysis," *Journal for the Scientific Study of Religion*, Volume 30, Issue 1 (March 1991):16.

[77]Saniotis, 485; Candace S. Alcorta and Richard Sosis, "Ritual, Emotion, and Sacred Symbols: The Evolution of Religion As an Adaptive Complex," *Human Nature*, Volume16 (April 2005): 334.

[78]Ibid., 333.

[79]Saniotis, 485.

monopolizes the verbal logical left hemisphere. Combined, repetitive movements and chanting occupy the lower cognitive functions of the "reacting" portions of the brain, enabling higher capacities of the right hemisphere to function freely.[80]

During the non-ordinary conscious state associated with liminality, previous cognitive models collapse, an entropic or disordered state ensues, and the brain is forced to make order of the new situation through novel conceptual integration of previously unconnected binary pairings.[81] Liminality, or the interaction of the higher and lower cognitive functions of the brains hemisphere, may foster novel conceptual integration and insight, which emerge as creative ideas to integrated into preexisting cognitive models.[82] As described in the following study, neurological research associates heightened brain activity in the upper right hemisphere with moments of insight.

John Kounios and Mark Beeman, two cognitive neuroscience researchers present research providing a deeper explanation of the brains hemispheric interaction during insight, as well, they provide information regarding the difference in brain activity during insight moments versus analytical or critical moments. In their study of brain activity during creative, insightful problem solving as well as more methodical, analytic problem solving, Kounios and Beeman found different patterns of brain activity in different parts of the brain. Prior research has implicated the brains right hemisphere in the processing of remote or weakly associated activities (trophotropic - nourish) and the left hemisphere in the processing of close or tightly associated

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[80]Saniotis, 486; B. Lex, "The Neurobiology of Ritual Trance," In *The Spectrum of Ritual: A Biogenetic Structural Analysis*, Ed. E. d'Aquili. (New York: Columbia University Press 1979): 126; C.D. Laughlin, Jr., "The Properties of Neurognosis," *Journal of Social and Evolutionary Systems* Volume 19, Issue 4 (1996): 370; Simonton, "Creativity as Blind Variation and Selective Retention," 312.

[81]J. McManus, "Ritual and Human Social Cognition," in *The Spectrum of Ritual: A Biogenetic Structural Analysis*, eds. E. d'Arquili, CD Jr Laughlin, and J. McManus (New York: Columbia University Press 1979): 239; Samoff Mednick, "The Associative Basis of the Creative Process, *Psychological Review* Volume 69, Issue 3 (May 1962): 220.

[82]Saniotis, 486; J. McManus, "Ritual and Human Social Cognition," 238.

activities (ergotropic - work).[83] Recall, as stated prior, creativity is the product of conceptually integrating remote, loose, or previously unassociated ideas.[84]

Using both electroencephalography (EGG) and functional magnetic resonance imaging (fMRI) Kounios and Beeman measured both the amount and type of brain activity produced during both insightful and analytic problem solving as well as the location of the activity in the brain. What they report is insightful solutions are associated with a burst of high frequency gamma activity just prior to the moment of insightful solutions in the right anterior superior temporal gyrus when compared to gamma activity of non-insightful solutions.[85] Recall the positive affect described during the Insight section that associates insight with positive feelings, and how this positive affect comes before the conscious assessment of the solution. During this increased right-brain hemisphere activity just prior to insight, the researchers also identified unexpected brain activity in the right rear of the brain. The researchers determined, immediately prior to the gamma burst associated with insight, a burst of slower alpha-band activity was measured over the right rear occipital cortex.[86] Alpha-band oscillations are the brain's dominant rhythm and are understood to reflect idling or inhibition of brain areas. In particular, such oscillations measured over occipital or visual cortex at the back of the head reflect a reduction in the amount of visual information passed from lower visual processing areas to higher functioning areas that perform more abstract computations. This process may represent the brain's attempt to diffuse its focus and reduce sensory gathering during moments of insight.[87] Prior neuroimaging

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[83]Kounios and Beeman, "The Aha! Moment," 214.

[84]Samoff Mednick, "The Associative Basis of the Creative Process, *Psychological Review* Volume 69, Issue 3 (May 1962): 221; Kounios and Beeman, "The Aha! Moment," 214.

[85]Ibid., 212-3.

[86]Kounios and Beeman, "The Aha! Moment," 212.

[87]Ibid., 213.

research has implicated the anterior cingulate brain section with cognitive processes like detection of weakly associated, inconsistent, or competing activities and attention switching,[88] all activities associated with creativity. Kounios and Beeman support this prior research by determining preceding a display of problems to be solved insightfully, an increase in neural activity in the anterior cingulate was detected. It appears, during insightful periods, the brain focuses inward by diffusing external stimuli in preparation for detection and retrieval of weakly activated potential solutions in the anterior cingulate.[89]

In contrast, Kounios and Beeman also identified that preceding a display of problems to be solved analytically, there was an increase in neural activity measured over the posterior (visual) cortex.[90] This greater neural activity measured by EEG over the visual cortex preceding analytical problem solving is hypothesized to reflect the amount of visual information passed along to higher cortical areas.[91] This increase of visual stimulus and location of the neural activity suggests that participants were preparing to direct their attention outward, looking for external visual cues or stimulation.[92]

Creative problem solvers seem to experience a greater diffusing of visual inputs during insight.[93] Previous findings suggest that highly creative individuals habitually deploy their attention in a diffuse rather than a focused manner.[94] Alternatively, when asked a difficult

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[88]Kounios and Beeman, "The Aha! Moment," 214.

[89]Ibid.

[90]Ibid.

[91]Ibid.

[92]Ibid.

[93]Ibid., 215.

[94]Kounios and Beeman, "The Aha! Moment,", 215.; P. Ansburg and K. Hill, 1142.

question, people often look away from the questioner, or even close his or her eyes in order to avoid distractions and to concentrate on thinking of the answer.[95] This study suggests that when a weakly activated problem solution is present in the right temporal lobe, a temporary reduction in interfering visual inputs facilitates the retrieval of this solution, allowing for conceptual integration, insight, and emergence.[96]

In a metareview, Dr. Arden Rosalind and colleges examined 45 published creative cognition studies containing imaging components to provide additional evidence supporting the conclusions of the Kounios and Beeman study. The studies used in the Rosalind review describe both absolute changes in the alpha band as well as functional couplings between brains regions associated with creative task performance.[97] The vast majority of EEG studies report either amplitude or power, and synchronization changes associated between creative task performance and brain alpha band activity. Alpha band activity has been associated with cognition and memory. Increases in Alpha band activity are more commonly associated with idling or inhibition of visual cortical regions of the brain, such as diffused visual activity during creative moments. Decreases of Alpha band activity is associated with task performance and alpha band suppression is associated with increased visual cortical activity typically associated with analytical cognition.[98]

Similar to the Kounios and Beeman study, Rosalind, et al found alpha band power changes in the right posterior brain regions in all similar remote association tests included in the review. This change in alpha band power has been interpreted to reflect low cortical activation,

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[95]Kounios and Beeman, "The Aha! Moment," 213.

[96]Ibid., 214.

[97]Rodalind Arden, Robert S. Chavez, Rachael Grazioplene, and Rex E. Jung, 144.

[98]W. Klimesch, "EEG Alpha and Theta Oscillations Reflect Cognitive and Memory Performance: A Review and Analysis," *Brain Research Reviews* Volume 29 Issue 2–3 (1999): 172.

defocused attention, and early unconscious solution-related processing, all activities associated with creativity.[99]

Dr. Arne Dietrich, a cognitive neuroscience researcher presents a study of neural activity of the prefrontal cortex during the moment of insight, value assessment and emergence. Recall, the basic definition of creativity is both novel and useful and that the subconscious brain evaluates and filters novel insights prior to moving them into conscious thought and emergence. Dietrich states, the prefrontal cortex integrates already highly processed information to enable still higher cognitive functions such as abstract thinking and cognitive flexibility.[100] If creativity were both novel and appropriate, it would appear that the prefrontal cortex's ability to evaluate value or usefulness is critical to the emergence of new and creative ideas.[101] The prefrontal cortex contributes highly to the conceptual integrative experience by recognizing new and novel combinations, evaluating for appropriateness, and allowing them to emerge into consciousness.[102]

Currently, researchers hypothesize the prefrontal cortex plays a vital role in the creative process. As stated prior, a novel insight emerges when it is represented in working memory buffer of the prefrontal cortex, which holds the content of consciousness, and becomes a conscious thought. Numerous insights turn out to be incorrect, incomplete, or trivial, so judging which insights to pursue and emerge into consciousness or which to discard requires prefrontal cortex

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[99]Rodalind Arden, Robert S. Chavez, Rachael Grazioplene, and Rex E. Jung, 144; Oshin Vartanian, Colin Martindale, and Jonna Kwiatkowski, "Creativity and Inductive Reasoning: The Relationship Between Divergent Thinking and Performance on Wason's 2-4-6 Task," Quarterly Journal of Experimental Psychology: Section A No. 56, Issue 4 (May 2003): 644; OM Razumnikova, "Creativity Related Cortex Activity in the Remote Associates Task," Brain Resolution Bulletin Volume 73, Issue 1-3 (June 2007): 96; Mark Jung-Beeman, Edward M. Bowden, Jason Haberman, Jennifer L. Frymiare, Stella Arambel-Liu, Richard Greenblatt, Paul J. Reber, and John Kounios, "Neural Activity When People Solve Verbal Problems with Insight," *PLoS Biology* Volume 2, Issue 4 (April 2004): 506.

[100]F. Lhermitte, B. Pillon, and M. Serdaru, "Human Autonomy and The Frontal Lobes Part I: Imitation and Utilization Behavior," *Annals of Neurology* Volume 19, Issue 4 (October 2004): 332.

[101] Dietrich, "The Cognitive Neuroscience of Creativity," 1013.

[102] Ibid., 1012.

integration and value assessment.[103] Sophisticated creative thought appears to be based on the prefrontal cortex's ability to integrate subconscious novel thoughts as they emerge into consciousness.[104] Once an insight emerges, the prefrontal cortex can than apply higher cognitive functions to the new idea, including central executive processes such as directing and sustaining attention, retrieving relevant memories, buffering that information and ordering it in space-time, as well as thinking abstractly and considering impact and further appropriateness.

However, research has also shown that the dorsolateral section of the prefrontal cortex, which is associated with managing and directing working memory and providing temporary representations of information when it conforms to known cognitive models, shows increased activity during surprise violations of previously learned associations.[105] This suggests novel combinations of information that contradict known mental models and conventional norms might have a lower threshold to enter conscious awareness to be represented in working memory.[106]

Evidence suggests the prefrontal cortex may be a central structure involved in creative thinking.[107] The fact that stored knowledge and novel combinations of that knowledge are implemented in two distinct areas of the brain is critical to understanding the relationship between knowledge and creativity, as well as the difference between creative and noncreative thinking.[108] Long-term memory is an available pool of information that can be used either by the prefrontal cortex to create a new and novel thought or by another neural sequence during non-creative

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[103]Ibid., 1015.

[104]Ibid.

[105]P. C. Fletcher, J. M. Anderson, D. R. Shanks, R. Honey, T. A. Carpenter, T. Donovan, N. Papadakis, and E. T. Bullmore, "Responses of Human Frontal Cortex to Surprising Events Are Predicted by Formal Associative Learning Theory," *Nature Neuroscience* Volume 4, Issue10 (October 2001): 1043.

[106]Dietrich, "The Cognitive Neuroscience of Creativity," 1016.

[107]Ibid., 1012.

[108]Ibid., 1014.

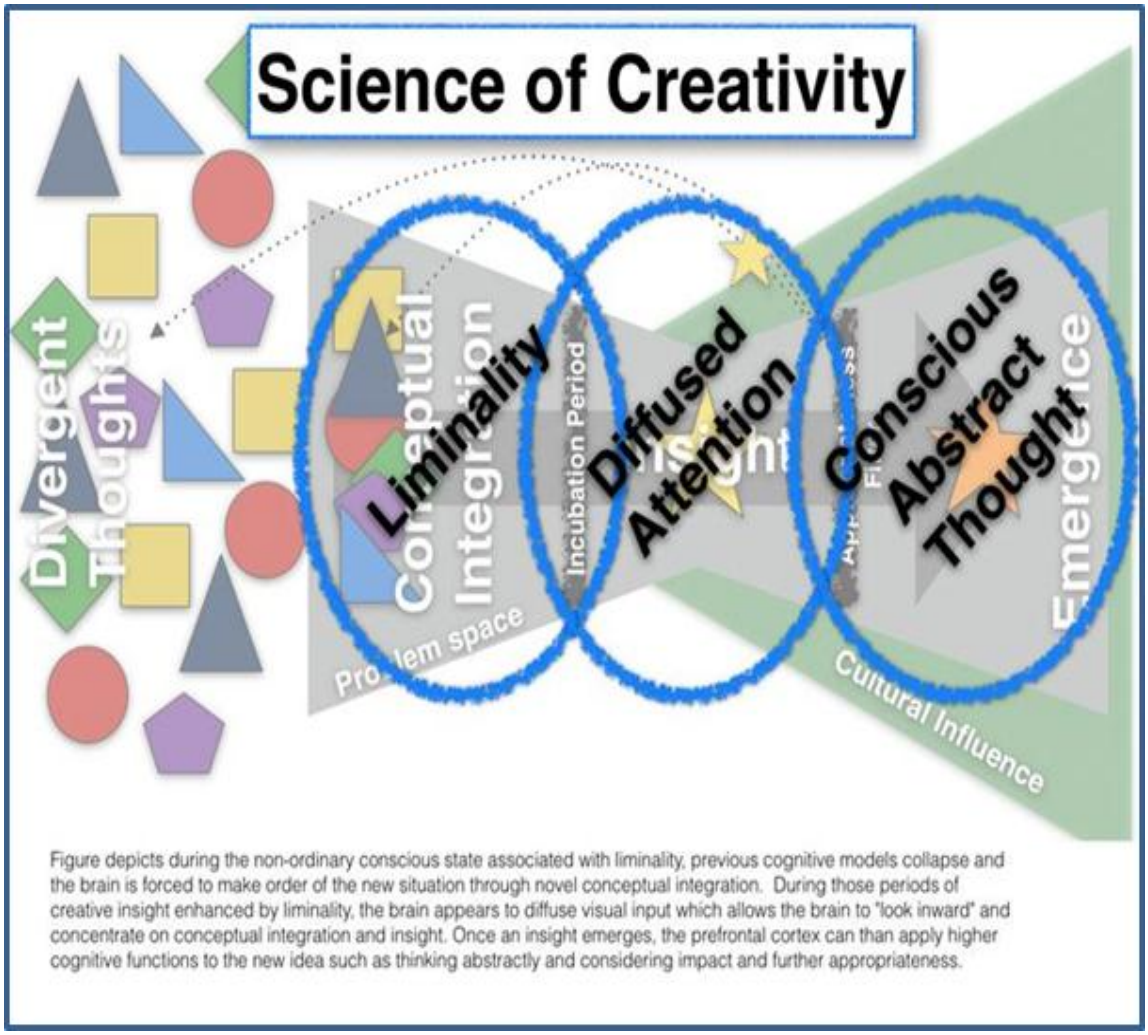

Figure 3: Science of Creativity[109]

analytical problem solving. As described in all the studies above, the periodic down regulation of the frontal attentional system allows insights to emerge into consciousness to be represented in working memory. Because there is no apparent effort or intention associated with these emerged

[109]T.Kurtz, Figure depicts during the non-ordinary conscious state associated with liminality, previous cognitive models collapse and the brain is forced to make order of the new situation through novel conceptual integration. During those periods of creative insight enhanced by liminality, the brain appears to diffuse visual input which allows the brain to "look inward" and concentrate on conceptual integration and insight. Once an insight emerges, the prefrontal cortex can than apply higher cognitive functions to the new idea such as thinking abstractly and considering impact and further appropriateness.

insights, they are often described as mysterious and described by such metaphors as "being hit by a ton of bricks," or the proverbial "light bulb turned on." [110]

Section Summary: How Does Divergent and Convergent Thinking Happen

The science of creativity bridges understanding a definition of creativity to potential creativity enhancers and limiters. During the non-ordinary conscious state associated with liminality, previous cognitive models collapse, an entropic or disordered state ensues, and the brain is forced to make order of the new situation through novel conceptual integration of previously unconnected binary pairings. During those periods of creative insight enhanced by liminality, the brain appears to diffuse visual input, which allows the brain to "look inward" and concentrate on conceptual integration and insight. Reduction in the amount of visual information passed from lower visual processing areas to higher functioning areas that perform more abstract computation may represent the brain's attempt to diffuse its focus and reduce sensory gathering during moments of insight. It is theorized the prefrontal cortex plays a vital role in the creative process as novel insight emerges into the working memory buffer of the prefrontal cortex and becomes a conscious thought. Sophisticated creative thought appears to be based on the prefrontal cortex's ability to filter and integrate subconscious novel thoughts as they emerge into consciousness. [111] Once an insight emerges, the prefrontal cortex can than apply higher cognitive functions to the new idea such as thinking abstractly and considering impact, and further appropriateness.

Liminality and diffused attention run somewhat contrary to American and western traditions. Liminality, or the establishment of non-ordinary conscious states, through mediation

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[110]Ibid., 1018.

[111]Dietrich, "The Cognitive Neuroscience of Creativity," 1015.

and ritual, is not often practiced or advocated in western professional spheres that often favor quick decisions. However, there is strong reason to believe that liminality promotes conceptual integration and can help overcome entrenched cognitive models and encourage new insightful opportunities. Diffused attention, or the ability to limit visual input, again, is not often practiced or advocated by western professional practices, which favors eye contact and constant "listening skills" interaction. Nonetheless, diffused attention is essential to novel insight. In combination, liminality and diffused attention promote conscious abstract thought and the emergence of creative understanding.

Creativity Enhancement and Inhibitors: Turning Understanding into Action

Even though there is no single attribute associated with increased or decreased levels of creativity, evidence suggests a core of attributes may be more strongly associated with either enhancing or inhibiting creativity. Researchers have developed inventories of attributes known to be associated with increased levels of creativity. Although many inventories and attributes have been identified, life experience diversity and cognitive diversity are identified as primary precursors and creativity enhancers. Additionally, avoiding early evaluation during problem solving, oppositional cognitive blending, diffused and down-regulated attention and positive moods are associated with enhanced creativity. In contrast, limited exposure to new and novel ideas or new problem solving examples, depth of knowledge, age, experience, and cognitive entrenchment are associated with creativity inhibition.

Creativity Enhancement: Increasing Creativity to Increase Understanding

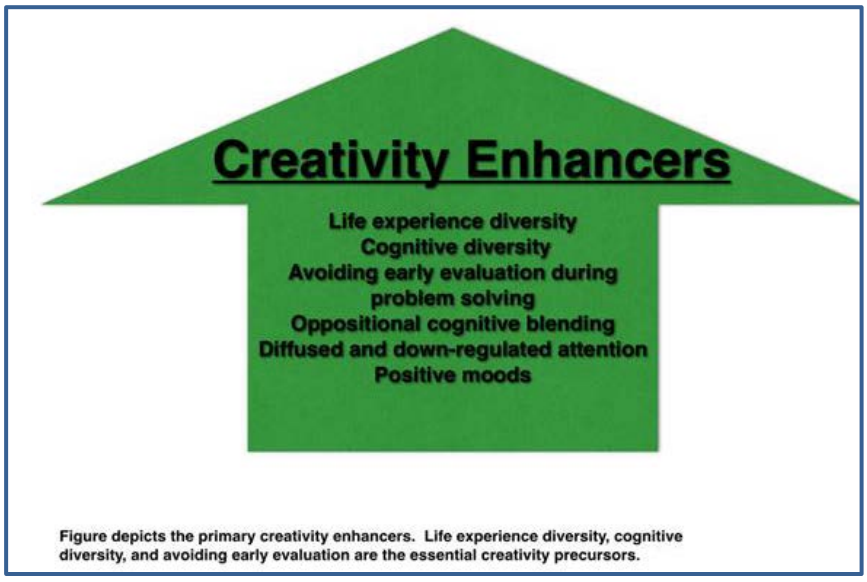

Figure 4: Creativity Enhancers

Creativity Inventories and Attributes: Diversity is Essential

Creativity tests and inventories measure specific cognitive processes such as thinking divergently and making associations through convergence, as well as provide common attributes associated with creativity[112]. To enhance creativity, the following inventories and attributes may indicate on which traits should be focused. Of note is the key role experience diversity and thought diversity play when assessing creativity.

The Creative Person Biographical Inventory (CPBI) measures five areas: family background such as educational level parents, degree of public recognition of parents or siblings. Intellectual and cultural orientation like interests and hobbies, level of availability of demanding literature, frequency of visits to museums or art galleries. Pervasive motivation defined as possession and use of special equipment such as a microscope, willingness to skip meals to work on a project, taking summer jobs in a field of interest. Breadth of interest regarding number of hobbies pursued, number of favorite school subjects, as well as drive towards novelty and diversity to include level of interest in unusual art forms, extent of unconventional collections such as spider webs.[113] In a three-year study of high school students, the CPBI correctly identified 96 per cent of the students whose products were rated by teachers as artistically creative.[114]

Similarly, the Life Experience Inventory (LEI) measures 49 items identified as creative and noncreative. These items are broadly categorized as self-striving or self-improvement, parental emphasis and striving, social participation and experience, and independence training. A

[112]Cropley, 72.

[113]Ibid., 74.

[114]Ibid.

study based on real-life achievements of 98 engineers found 83 per cent of the engineers who met the studies independent creativity criteria also rated as creative according to the LEI.[115]

The Creative Activities Checklist (CAC) asks participants to specify how frequently they have participated in real-life activities in six areas: literature, music, drama, arts, crafts, and science. In two separate studies, these activities were associated with creativity with statistical reliabilities in excess of 90 per cent.[116]

Although not an inventory or checklist, a 30-year longitudinal study of college women concluded that youthful openness and unconventionality were strongly predictive of adult creative achievement when associated with knowledge depth, commitment, and self-discipline.[117] Additionally, research has also identified other factors that may account for the degree of creativity associated with problem solving such as: task motivation, interest, and commitment; domain-relevant knowledge and technical skills; and creativity-relevant processes such as the ability to break mental sets and heuristics during idea generation.[118] Researchers have also examined the creative sub-processes of creative and noncreative students and found highly creative students spend greater time generating new information or hypotheses, developing hypotheses, and self-reference or self-criticism than less creative students.

As essential as diversity, a final important creativity attribute is avoiding early evaluation during the problem-solving process. Creative and noncreative problem solving may involve the

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[115]Ibid.

[116]Mark A. Runco, "Creativity," *Annual Review of Psychology* Volume 55, Issue 1(2004): 674; Sandra W. Russ, Andrew L. Robins, and Beth A. Christiano, "Pretend Play: Longitudinal Prediction of Creativity and Affect in Fantasy in Children", *Creativity Research Journal* Volume 12, Issue 2 (1999): 134; Cropley, 72.

[117]Helson, Ravenna Helson, "A Longitudinal Study of Creative Personality in Women," *Creativity Research Journal* Volume 12, Issue 2 (1999): 89; Cropley, 78.

[118]Lubart, "Models of the Creative Process," 303; Conti, Coon, Amabile, 388.

same sub-processes but in different sequences.[119] Research indicates creative problem solving is proceed by a search for relevant information followed by defining the problem, whereas less creative or noncreative problem solving begins with a defined problem.[120] One of the proposed primary characteristics of the creative process is deferred judgment of ideas because early evaluation can reject new ideas that need time to be developed.[121] In addition, it has been documented that second interpretations of similar pairs result in more emergent properties, indicating people may initially use the easiest interpretation then reengage in a more creative manner during a second interpretation.[122]

Life experience diversity and cognitive diversity paired with avoiding early evaluation during problem solving are the principal creativity enhancers. Both enhancers enable the conceptual integration of divergent thoughts and insight. Diversity is vital to widening the pool of available elements to generate creativity, however, if creative ideation is stymied by early evaluation and adherence to presupposed cognitive models, the creative process falters. Just as liminality and diffused attention are not typical western professional traits, neither are diversity and avoiding early evaluation, which run contrary to specialization and immediate problem identification and solution.

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[119]Lubart, "Models of the Creative Process," 302.

[120]David Perkins, Eileen Jay, and Shari Tishman, "New Conceptions of Thinking: From Ontology to Education," *Educational Psychologist* Volume 28, Issue 1 (1993): 71.

[121]J.P. Guilford, "Creativity: Retrospect and Prospect," *Journal of Creative Behavior* Volume 4, Issue 3 (1970): 58; Simonton, "Creativity as Blind Variation and Selective Retention," 312; Runco, 661.

[122]Merryl J. Wilkenfeld and Thomas B. Ward, "Similarity and Emergence in Conceptual Combination," *Journal of Memory and Language* Volume 45, Issue 1 (July 2001): 25; T. Ward, "Creative Cognition as a Window on Creativity," 35; Simonton, "Creativity as Blind Variation and Selective Retention," 312.

Oppositional Cognitive Blending: Blending Differences May Be More Important Than Blending Similarities

One of the most common creative processes is conceptual integration, the combining of previously separate elements such as words, concepts, and visuals forms so that new unexpected properties, discoveries, or insights emerge. Whether in science, technology, art, music, literature, or other creative realms, conceptual integration is accepted as a creativity stimulant.[123] Conceptual Integration clearly relies on accessing stored knowledge, but some ways of accessing knowledge may be more conducive than others to the development of original ideas.[124] Evidence suggests accessing conceptual information at varying degrees of specificity effects creativity generation and originality. In one study, participants were instructed to either think of a specific example of an animal while others were instructed to consider the abstract attributes required for animals to survive. Rated originality was lowest in the specific example condition and highest in the abstraction condition.[125] Creativity studies have also demonstrated that compositions of image and text increases emergent capacity when compared to emergent capacity from linear text.[126] Image-text compositions enable easer blending of integrated collections of information when compared to alternative list and spatial text and increase emergence.[127]

Of primary importance however, *research has demonstrated dissimilar combinations result in more emergent properties than similar combinations*, and there is strong evidence suggesting opposition component blending may be more important to emergence than similar

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[123]T. Ward, "Creative Cognition as a Window on Creativity," 34.

[124]Ibid., 30.

[125]S. Smith, T. Ward, and R. Finke, 838; T. Ward, "Creative Cognition as a Window on Creativity," 33.

[126]Kerne, S. Smith, Koh, Choi, and Graeber, "An Experimental Method for Measuring the Emergence of New Ideas," 461.

[127]Ibid., 468, 472.

component blending.[128] Investigators assessed emergence in opposing versus non-opposing concepts such as friendly-enemy and complex-simplicity versus hostile-enemy and clear-simplicity. As hypothesized, opposing concepts yielded more emergent properties than similar concepts.[129] Other research has also explored opposition thinking, and likewise concluded that when the study component objects were more dissimilar, people generated more original outcomes, however the outcomes were also judged to be of lower quality.[130]

"Homospatial" thinking, a concept defined as "actively conceiving two or more discrete entities occupying the same space"[131] has been demonstrated to stimulate creativity in art students. Art students were shown two slides simultaneously of either harmonious or discordant imagery either side-by-side or superimposed. The greatest artistic originality and quality resulted from superimposed, discordant images. The images that had the most extreme disjointed content, mood, colors, patterns, and themes contained in the same space, stimulated the most creative outputs. Additionally, the more discordant images tended to produce more original and novel work as opposed to merely grouping the dissimilar images.[132] Additionally, researchers observed art students as they created drawings of provided objects and recorded the number of objects manipulated, time spent exploring the objects, and the unusualness of the objects selected to

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[128]Merryl J. Wilkenfeld and Thomas B. Ward, "Similarity and Emergence in Conceptual Combination," *Journal of Memory and Language* Volume 45, Issue 1 (July 2001): 22; T. Ward, "Creative Cognition as a Window on Creativity," 35.

[129]Ward, "Creative Cognition as a Window on Creativity," 35.; Estes and T. Ward, "The Emergence of Novel Attributes," 151; M. Mumford et al.,"Process-based Measures of Creative Problem-Solving Skills," 38.

[130]T. Ward, "Creative Cognition as a Window on Creativity," 35.

[131]Baughman and Mumford, 37; A. Rothenberg, *The Emerging Goddess: The Creative Process in Art, Science and Other Fields*, (Chicago: University of Chicago 1976):18.

[132]Goldstein, "Emergence, Creativity, and the Logic of Following and Negating," 5.

draw. Originality ratings correlated positively with the number of objects manipulated and the time each object was explored in detail correlated significantly with originality.[133]

Similar to oppositional conceptual integration, working and engaging in dynamic environments, in which novel and divergent elements are continuously injected into the creativity process, requires individuals to perform constant conceptual integration. "Dynamic environments require individuals to respond to changing conditions by making a series of interdependent decisions in real time."[134] In dynamic and often complex environments, what is expected to happen often does not, challenging preset mental models.[135] During times when actual outcomes do not equal expected outcomes, creative individuals accept "… a wide range of possibilities, options, and information into their cognitive processes and adapt their mental models to include the new novel information, as opposed to relying on a limited set of inputs."[136] Research shows the *inherent uncertainty of dynamic environments requires production of new perspectives, which may enhance conceptual integration and insight by reducing reliance on established habitual behavior*.[137]

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[133]Lubart, "Models of the Creative Process," 303.

[134]Maria Angeles Gonzalez, Alfredo Campos, and Maria Jose Perez, "Mental Imagery and Creative Thinking, *The Journal of Psychology* Volume 131, Issue 4 (July 1997): 142; J.P. Guilford, "Creativity: Retrospect and Prospect," 58.

[135]K. Locke, K. Golden-Biddle, and M. Feldman, "Making Doubt Generative: Rethinking the Role of Doubt in the Research Process," *Organization Science* Volume 19, Issue 6 (2008): 915; Karl Weick, "The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster," *Administrative Science Quarterly* 38: 639.

[136]P. Atkins, R. Wood, and P. Rutgers, "The Effects of Feedback Format on Dynamic Decision Making," *Organizational Behavior and Human Decision Processes* Volume 88, Issue 2 (2002): 588; Weick, Sutcliffe, Obstfeld, "Organizing and the Process of Sensemaking," 411; C. Gonzalez, Lerch, and Lebiere, "Instance-based Learning in Dynamic Decision Making," *Cognitive Science* Volume 27, Issue 4 (2003): 592.

[137]Locke, Golden-Biddle, and Feldman, "Making Doubt Generative," 912; Dane, "Reconsidering the Trade-Off between Expertise and Flexibility," 588.

Very similar to when people engage in dynamic environments, focusing attention on extra domain interests increases the collection of novel and divergent elements available for conceptual integration. Individuals are more likely to encounter exceptions, or counterexamples, of their current mental models the more varied and diverse their extradomain interests are. This increases the potential to conceptually integrate a wider array of unconnected ideas. "It typically takes a novel stimulus – either a new piece of information or getting out of the environment in which an individual has become comfortable – to jolt attentional systems awake and reconfigure both perception and imagination."[138] Research indicates that many successful scientists tend to have strong artistic, literary, or musical extra domain interests.[139] Additionally, evidence suggests job or specialty related problem-solving capabilities increases in subjects who participate in extra-domain hobbies.[140]

The Ability to Diffuse or Down Regulated Attention: Allowing Creativity to Happen

Individuals high in creativity often diffuse their attention rather than a use it in a focused manner.[141] Altered states such as dreaming or daydreaming can play an essential part in the conceptual integration process. Daydreaming is an altered state of consciousness attributable to prefrontal cortex down-regulation, albeit not as profound as dreaming.[142] *During downregulated times, the attentional system diffuses, and ideas, unobstructed by societal norms and constraints*

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[138]Dane, "Reconsidering the Trade-Off between Expertise and Flexibility," 588-9.

[139]R. Root-Bernstein et al., "Arts Foster Scientific Success: Avocations of Nobel, National Academy, Royal Society, and Sigma Xi members," *Journal of Psychology of Science and Technology* Volume 1, Issue 2 (2008): 54; R. Root-Berstein, M. Bernstein, and H. Garnier, "Correlations Between Avocations, Scientific Style, Work Habits, and Professional Impact of Scientists," *Creativity Research Journal* Volume 8, Issue 2 (1995): 115.

[140]Dane, "Reconsidering the Trade-Off between Expertise and Flexibility," 593.

[141]Kounios and Beeman, "The Aha! Moment," 215; P. Ansburg and K. Hill, 1142.

[142]Dietrich, "Functional Neuroanatomy," 238.

and unfiltered by rational conventions form in working memory.[143] In this downregulated state, thinking is characterized by unmethodical drifting, and the order of thoughts emerging into consciousness is more chaotic, permitting more "loosely connected" associations to emerge.[144]

Impasses during problem solving are typical, especially creative problem solving when new associations must be formed. However, creative impasses may be overcome by the relaxation of constraints.[145] Incubation, which "… refers to the process of removing a problem from conscious awareness temporarily as a means of gaining new perspectives on how to solve it"[146] is another method to down-regulate and relax constraints to overcome impasses. It is possible that incubation is successful because it leads to constraint relaxation and spontaneous processing modes, which may result produce spreading of active memory and attention broadening, passive forgetting of problem details or failed entrenched ideas and the use of chance environmental cues to provoke new ideation.[147] A common recorded phenomenon is the experience of vigorously trying for hours to solve a problem only to have an "A-ha!" moment of solution discovery while performing something unrelated.

During creative problem solving, impasses and cognitive stalls may occur after the preparatory phase when the analytic mind reaches its limit. Between incubation and the moment

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[143]Simonton, "Creativity as Blind Variation and Selective Retention," 312; Dietrich, "Functional Neuroanatomy," 237.

[144]Dietrich, "The Cognitive Neuroscience of Creativity," 1016.

[145]G. Knoblich, S. Ohilsshon, H. Haider, and D. Rhenius, "Constraint Relaxation and Chunk Decomposition in Insight Problem Solving," *Journal of Experimental Psychology* Volume 26, Issue 6 (1999): 1535.

[146]R. A. Finke, "Imagery, Creativity, and Emergent Structure," *Consciousness and Cognition* Volume 5, Issue 3 (September 1996): 389.

[147]R.Olton and D. Johnson, "Mechanisms of Incubation in Creative Problem Solving," *American Journal of Psychology* Volume 89, Issue 4 (1976): 617; J.P. Guilford, "Some Incubated Thoughts On Incubation," *Journal of Creative Behavior* Volume 13, Issue 1 (1979):1; Dietrich, "The Cognitive Neuroscience of Creativity," 1019; Lubart, "Models of the Creative Process," 298.

of illumination, there are often “points of creative frustration” when creativity is blocked, however, this frustration may promote incubation[148]. At this point, one can either restart, potentially running into the same cognitive block, accept a noncreative solution, or push ahead, exploring further alternatives or moving in a new direction, perhaps re-conceptualizing the problem. Thus, the point of creative frustration involves making a decision on how to deal with difficulties encountered during problem solving.[149] During downregulated and diffused attentional states, societal norms, constraints, and predetermined cognitive models dissolve and permit conceptual integration and insight.

Mood: The Importance of Positivity on Creative Problem Solving

Research has also examined how mood can influence insight and creativity, suggesting subjects with positive moods have increased problem solving quantity versus subjects with neutral and negative moods.[150] Other research suggests that during periods of positive mood, inhibiting attentional regulation is decreased allowing "irrelevant" or non-filtered information to be processed by the brain, increasing opportunity for creativity.[151] Additionally, a recent fMRI study demonstrates people are more likely to solve problems with insight if they are in a positive mood rather than a neutral or negative one.[152] Moreover, positive mood is associated with greater anterior cingulate brain activity during the preparation phase prior to each problem, "…this

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[148]D. Sapp, “The Point of Creative Frustration and the Creative Process: A New Look at an Old Model,” *Journal of Creative Behavior* Volume 26, Issue 1 (1992): 24.

[149]Lubart, “Models of the Creative Process,” 298.

[150]Kounios and Beeman, “The Aha! Moment,” 216.

[151]Renée K. Biss, Lynn Hasher, and Ruthann C. Thomas, “Positive Mood is Associated with the Implicit Use of Distraction,” *Motivation and Emotion* Volume 34, Issue 1 (2010): 74; Kounios and Beeman, “The Aha! Moment,” 215.

[152]K.J. Subramaniam, Kounios, TB Parrish, and M. Jung-Beeman, “A Brain Mechanism for Facilitation of Insight by Positive Affect,” *Journal of Cognitive Neuroscience* Volume 21, Issue 3 (2009): 415; Kounios and Beeman, “The Aha! Moment,” 216.

suggests positive mood biases cognitive control mechanisms that facilitate insight and negative moods have the opposite effect."[153]

Creativity Inhibitors: Limiting Creativity and Limiting Understanding

Just as creativity can be enhanced by the nontypical western professional factors like increased diversity and delayed evaluation during problem solving, creativity can also be inhibited in many ways. Oddly, creativity-inhibiting factors are characteristic to western professional success centered on specialization and swift and determined problem solving. Some primary inhibitors of creativity include limited exposure to new examples, problems or problem-solving methods, increased knowledge depth, experience and age, as well as increased field expertise, which can result in cognitive entrenchment.

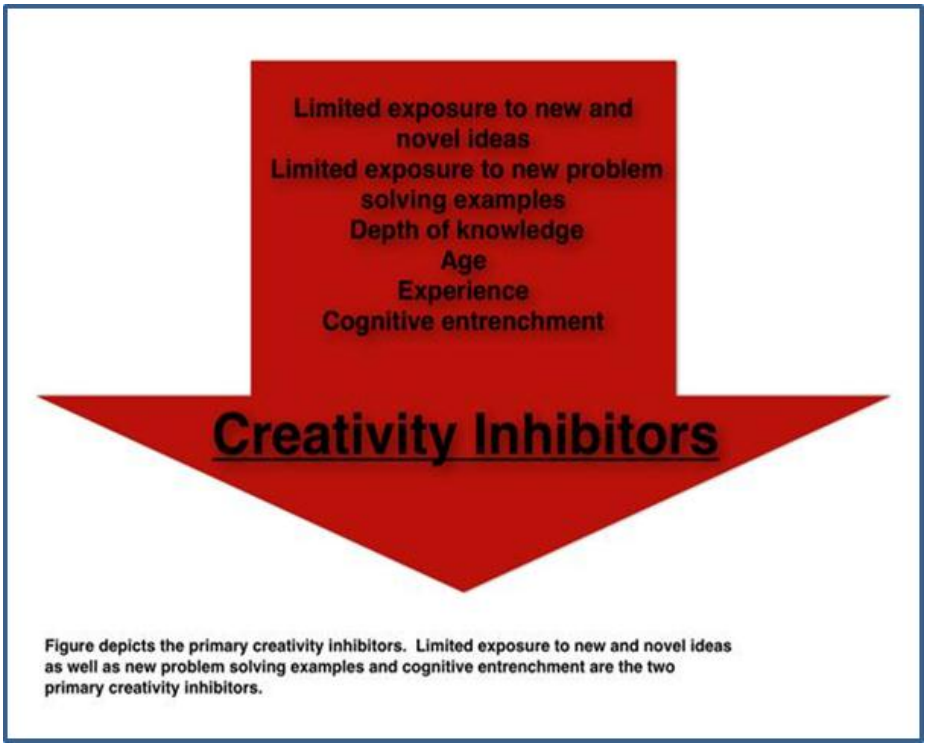

Figure 5: Creativity Inhibitors[154]

[153]Ibid., 215.

Limited Exposure to New Examples, Problems, or Problem Solving Methods: Diversity is Essential – Again

Readily available examples are most likely used during creative task performance.[155] For ordinary, as opposed to revolutionary, creative accomplishments people primarily access highly specific solutions to prior problems and create new solutions from them. The retrieval and selection of an instance is theorized to be guided by the accessibility of the instances – the more accessible the example is, the more likely it will be used as a starting point in developing a new idea.[156] This might generate a rapid solution but also transfers unknown properties or unnecessary constraints into the new solution, and as expected are lower in originality than creations developed using other forms of information retrieval.[157] This approach to the generation of creative new products appears to avor practicality over unrealistic or impractical originality.[158]

Ward's Path of Least Resistance model suggests, that the tendency to generate creative tasks by applying one or more specific, readily available instances to form a novel creation.[159] During research designed to assess the frequency specific examples are relied on to generate novel ideas and if using specific examples effects the rated originality of a novel idea, subjects were asked to create a mythical space animal. The percentage of subjects who reported relying on

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[154]T. Kurtz, Figure depicts the primary creativity inhibitors. Limited exposures to new and novel ideas as well as new problem solving examples coupled with cognitive entrenchment are the two primary creativity inhibitors.

[155]Estes and T. Ward, "The Emergence of Novel Attributes," 150; T. Ward, "Creative Cognition as a Window on Creativity," 32.

[156]T. Ward, "Creative Cognition as a Window on Creativity," 30; M. Mumford et al.,"Process-based Measures of Creative Problem-Solving Skills," 57.

[157]T. Ward, "Creative Cognition as a Window on Creativity," 30; Merryl J. Wilkenfeld and Thomas B. Ward, "Similarity and Emergence in Conceptual Combination," *Journal of Memory and Language* Volume 45, Issue 1 (July 2001): 25.

[158]T. Ward, "Creative Cognition as a Window on Creativity," 30.

[159]Ibid.

previous animal examples while developing their imaginary animal was 68 percent.[160] This indicated that accessing common examples during creative tasks tends to be used by roughly two thirds of people; however, more importantly, the creations produced by the 68 per cent were rated as less original than those developed by subjects reporting using alternative approaches.[161] Other research has repeated this trend, in a study to test "design fixation" researchers exposed subjects to specific examples and specifically instructing the subjects not to use the examples during creative idea generation, more than half of the subjects reported using the recently experience examples during a creative task.[162] In similar research, participants were instructed to arrange geometric patterns into complex combinations, some groups were informed of a category they should arrange the shapes into, such as vehicles or tools, another was only told to arrange the shapes, and then after they arranged the shapes, they were informed to assign them into a category. The subjects who were instructed to arrange shapes into certain categories produced fewer and rated less original creative outputs than those who arranged combinations first, then categorized them.[163] This research suggests that restricting creative outputs to specific categories limits creativity.

The use of specific examples or focusing on specific categories of examples may limit creativity, however it may improve acceptance of the creative output. Research has shown that creations that relied least on specific examples and rated highest in originality and abstraction

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[160]T. Ward, M. J. Patterson, C. Sifonis, R. A. Dodds, and K. N. Saunders, "The Role of Graded Structure in Imaginative Thought," *Memory and Cognition* Volume 30:199 (2004): 2.

[161]T. Ward, "Creative Cognition as a Window on Creativity," 32; T. Ward, M. J. Patterson, C. Sifonis, R. A. Dodds, and K. N. Saunders, "The Role of Graded Structure in Imaginative Thought," *Memory and Cognition* Volume 30:199 (2004): 7.

[162]Jansson and Smith 1991 p11, T. Ward, "Creative Cognition as a Window on Creativity," 32.

[163]Ibid., 36.

were rated as less appealing and less practical than those creations that relied on specific examples and that were rated as less original.[164]

Depth of Knowledge, Experience and Age: Essential for Creativity, but too Much Limits Creativity

Depth of knowledge, experience and age typically combine to inhibit creativity. All three elements are associated with rigid mental models and decreased cognitive flexibility. Creativity researchers hypothesize that "the relationship between knowledge and creativity is best described by an inverted U function."[165] Increased knowledge is positively associated with increased creativity to a certain point. However, at that certain point, a negative association begins and knowledge continues to increase but creativity declines.[166] Recall the earlier proposed definition of creativity defines creativity as a combination of divergent thinking and usefulness. Usefulness is generally a product of knowledge gained through experience; however, researchers have demonstrated that too much knowledge may actually dampen creativity resulting in the inverted U relationship between knowledge and creativity.[167] It appears as knowledge increases reliance on rigid mental models and specific past examples increases as well.[168] In combination, these effects potentially inhibit creativity by limiting and constraining the divergent thinking essential for creativity.

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[164]Ibid., 33; T. Ward, M. J. Patterson, C. Sifonis, R. A. Dodds, and K. N. Saunders, "The Role of Graded Structure in Imaginative Thought," *Memory and Cognition* Volume 30:199 (2002): 200.

[165]Dietrich, "The Cognitive Neuroscience of Creativity," 1020.

[166]R. Weisberg, "Creativity and Knowledge: A Challenge to Theories," in *Handbook of Creativity*, ed. R. J. Sternberg (New York: Cambridge University Press 1999): 219.

[167]R.J. Sternberg, "The Nature of Creativity," *Creativity Research Journal* Volume 18, Issue 1 (2006): 87.

[168]Simonton, "Creativity as Blind Variation and Selective Retention," 320.

Perception and cognition rely heavily on preconceived mental models developed through experience and increased knowledge.[169] Creativity research provides evidence that reliance on preconceived mental models during deliberate conscious problem solving can hinder creative solutions.[170] Deliberate problem solving using a logical cause and effect model allows for focused cognitive capacity, but "tends to exclude creative divergent associations"[171] and may limit possible solutions.[172] Evidence seems suggest that problem solutions violating preconceived heuristics are not readily considered in deliberate problem solving efforts due to efficient and inflexible mental model gained through experience.[173] "Creative thinking by definition goes beyond knowledge."[174]

As we age, research indicates that we are less able to go beyond knowledge-based solutions or the ingrained mental models we have constructed during increased depth of knowledge and experience.[175] Consequently, creative achievements tend to peak in mid-life at the apex of prefrontal cortex capacity.[176] A metareview of how age effects creativity states, "…we can now conclude with great confidence that creative output tends to be a negatively associated with age."[177] However, the review stated the relationship between creativity and age does vary by

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[169]Dietrich, "The Cognitive Neuroscience of Creativity," 1016.

[170]Sternberg, "The Nature of Creativity," 92.

[171]Sarnoff Mednick, "The Associative Basis of the Creative Process," 220.

[172]Dietrich, "The Cognitive Neuroscience of Creativity," 1016.

[173]Ibid.

[174]R. Weisberg, "Creativity and Knowledge: A Challenge to Theories," in *Handbook of Creativity*, ed. R. J. Sternberg (New York: Cambridge University Press 1999): 226.

[175]Runco, 659.

[176] Dietrich, "The Cognitive Neuroscience of Creativity," 1021.

[177] Simonton, "Creativity as Blind Variation and Selective Retention," 322.

professional domain, the typical height of "…creativity occurs between the ages of 35 and 39, mathematicians and musicians reach their prime earlier, while historians and philosophers peak later."[178] This phenomenon is addressed in the Planck hypothesis, which theorizes that younger scientists are more receptive to innovation.[179] A list of eminent physicists including Bohr, Chadwick, Einstein, Fermi, Feynman, Gell-Mann, Heisenberg, Pauli, and Rutherford serve as anecdotal evidence supporting the Planck hypothesis that revolutionary advances in science, especially theoretical sciences, are predominantly associated with scientists in the 20s and newly beginning their career.[180] In addition, scientists who make revolutionary contributions at the onset of careers rarely make a second one as their age and careers advance, suggesting that age and associated solidified mental models are the responsible theme as opposed to individual capabilities.[181] Age related creativity decline and inclination to maintain outdated mental models may be amplified by the fact that "mental states that enable the spontaneous processing mode, such as daydreaming, go dramatically down with age."[182] Recall, previously mentioned scientific evidence of the importance of alternate states and diffused attention in the creativity process. As we age, the deliberate processing mode of problem solving becomes dominant and solutions consistent with a person's ingrained mental model and beliefs are preferred. It seems that, as we age, "a certain version of reality becomes so "hardwired" through decades of reinforcement that the continuously diminishing ability for cognitive flexibility is overpowered."[183]

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[178]Ibid.; Dietrich, "The Cognitive Neuroscience of Creativity," 1021.

[179]D. Hull, P. Tessner, and A. Diamond, "Planck's Principle," *Science* Volume 202, Issue 4369 (1978): 718.

[180]Dietrich, "The Cognitive Neuroscience of Creativity," 1021.

[181]Ibid.

[182]Dietrich, "Functional Neuroanatomy," 246.

[183]Deitrich , "The Cognitive Neuroscience of Creativity," 1022.

Cognitive Entrenchment: The Downside of Success and Experience

Cognitive entrenchment is defined "as a high level of stability in one's domain schemas, this stability tends to increase as individuals attain expertise within a given domain."[184] Cognitive entrenchment tends to occur to successful experts within their chosen field of work who have received positive feedback validating their mental models over many years. This increased expertise for many reasons is associated with increased professional achievement; however, *increased experience and long-term success tend also to be associated with cognitive inflexibility*, fixation on limited problem solving techniques that produce essentially the same solutions, and an inability to adapt to new conditions or relate to outlier types of data. Although successful job performance relies on expertise, it may also encourage inflexible cognitive models and promote cognitive entrenchment, which limits an expert's ability to adapt to novel situations or generate divergent and creative ideas.[185]

Expertise and effective decision-making are associated with elevated job performance.[186] Expertise is reliant on "high level of domain-specific knowledge acquired through experience."[187] Research has also shown that elite experts within specific professions tend to have accumulated at least ten years of practice and training within their specialty.[188] Years of experience coupled with

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[184]Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 579.

[185]Ibid.

[186]H. Dreyfus and S. Dreyfus, "Peripheral Vision: Expertise in Real World Contexts," *Organizational Studies* Volume 26, Issue 5 (2005): 787; Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 579.

[187]H. Dreyfus and S. Dreyfus, "Peripheral Vision," 788; K. Ericsson and P. Ward, "Capturing the Naturally Occurring Superior Performance of Experts in the Laboratory," *Current Directions in Psychological Science (Sage Publications Inc.)* Volume16, Issue 6 (2007): 346.

[188]K. Ericsson, Roring, and Nandagopal, "Giftedness and evidence for reproducing superior performance,"*High Ability Studies* Volume 18, Issue 1 (2007): 15.

successful job performance and accurate, positive performance-related feedback leads an expert to continued advancement within their field.[189]

However, expertise also produces limitations.[190] Research indicates that as expertise is acquired, cognitive flexibility may be lost.[191] Despite the benefits of expertise and its potential advantage during deliberate problem-solving research suggests that as expertise increases individuals tend to develop rigid cognitive models. Rigid cognitive models coupled with an inability to view problems from alternative perspectives, and an inability to adapt to new rules, mental models, and environmental conditions may limit an expert's creative capacity.[192]

Examples of mental model rigidity and cognitive inflexibility include the inability to predict or understand how non-experts will problem solve in the experts field.[193] As well as, experts display a reduced ability to adapt and conform to new rules and principles.[194] These

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[189]Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 580.

[190]C. Heath and N. Staudenmayer, "Coordination Neglect: How Lay Theories of Organizing Complicate Coordination," *Research in Organizational Behavior* Volume 22 (2000): 187; Pamela J. Hinds, Michael Patterson, and Jeffrey Pfeffer, "Bothered by Abstraction: The Effect of Expertise on Knowledge Transfer and Subsequent Novice Performance," *Journal of Applied* Psychology Volume 86, Issue 6 (December 2001): 1232.

[191]S. Lewandowsky, D. Little, and M. Kalish, "Knowledge and Expertise," in *Handbook of Applied Cognition, 2nd edition*, ed. D. Durso and S. Nickerson, (Chichester: John Wiley & Sons 2008): 87; Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 579.

[192]C. Camerer, G. Lowenstein, and M. Weber, "The Curse of Knowledge in Economic Settings," *Journal of Political Economy* Volume 97, Issue 5 (1989): 1243; Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 579.

[193]Birch and Bloom, "The Curse of Knowledge in Reasoning about False Belief," *Psychological Science* Volume 18, Issue 5 (2007): 382; C. Camerer, G. Lowenstein, and M. Weber, 1243; P. Hinds and M.J. Patterson, "Bothered by Abstraction," 1235; Pamela Hinds and Jeffrey Pfeffer, "Cognitive and Motivational Factors Affecting the Transfer of Expertise," *Why Organizations Don't Know What They Know* (2003): 7-8; Brian Warsink, Robert J. Kent, and Stephen J. Hoch, "An Anchoring and Adjustment Model of Purchase Quantity Decisions," *Journal of Marketing Research* Volume 35, Issue 1 (February 1998): 73-75.

[194]Peter A. Frensch and Robert J. Sternberg, *Advances in the Psychology of Human Intelligence*, Volume 5 (England: Lawrence Erlbaum Associates, Inc. 1989): 159-161; Garry Marchant, John Robinson,

findings suggest cognitive entrenchment is a result of a relationship between increased field expertise and a resulting cognitive inflexibility.[195]

As mentioned, expertise is gained through continual training, practice, performance, and positive feedback over approximately a 10-year period. During that period, all the components of an expert's mental model are likely to be tested through reasoning and application countless times. Due to the years it takes to develop an expert's complex cognitive model, it tends to be richer in detail, be more accurate, and provide greater associations to other models than non-expert models. However, what research has shown is the same attributes that contribute to an expert's success may also make their mental model resistant to modification. Continued use and positive affirmation tends to fix an expert's cognitive model to such an extent that adaptation becomes unlikely and cognitive entrenchment sets in.[196]

Cognitive Entrenchment, Fixation, and the Inability to Adapt

Domain expertise may enhance an individual's advanced deliberate problem solving skills and increase the ability to solve problems that conform to that specific method.[197] What if the problem presented does not conform to the preferred method and the default solution method or solution is suboptimal? Solution fixation occurs when an expert is unable to produce alternate solutions due to constraint to a specific problem solving technique. Fixation most likely occurs when experts are cognitively entrenched, "consequently, for those high in cognitive

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Urton Anderson, and Michael Schadewald, "Analogical Transfer and Expertise in Legal Reasoning," *Organizational Behavior and Human Decision Processes*, Volume 48, Issue 2 (April 1991): 273-4.

[195]Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 583.

[196]S. Taylor, "Asymmetrical Effects of Positive and Negative Events," *Psychological Bulletin* Volume 110, Issue 1: 68.

[197]M. Chi et al., "Categorization and Representation of Physics Problems by Experts and Novices," *Cognitive Science*, Volume 5, Issue 2 (1981):149; Larkin et al., "Expert and Novice Performance in Solving Physics Problems," *Science* Volume 208, Issue 4450 (1980) 1339.

entrenchment, it may prove difficult to devise solutions beyond those initially activated when presented with a problem."[198] Research describes that people trained using a specific problem solving technique are "often unable to solve problems that are similar in appearance but different in terms of their requisite solution method."[199] To the expert, the situation is identified as similar to past situations which have been solved using a specific default solution and the first idea that comes to mind, "triggered by previous experience with similar situations, prevents alternatives from being considered."[200] An unyielding entrenched expert's cognitive model may consistently produce suboptimal solutions and prevent other possible solutions from emerging.[201] Experts within a domain can become so reliant on particular methods that it limits the ability to produce alternative solutions and they become fixated on the solution they can produce - not the best solution.[202]

Related to fixation is an expert's inability to adjust to novel or new demands beyond their established mental models. Research indicates that the "scope of experts' inflexibility extends beyond fixation effects, and that adaptation—adjusting to novel task demands—can be a challenge for experts."[203] An expert's inability to adapt to new models is likely associated with

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[198]Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 584.

[199]A.S. Luchins and E.H.Luchins, "Task Complexity and Order Effects in Computer Presentation of Water Jar Problems," *Journal of General Psychology* Volume 118, Issue 1 (1991): 69; M. Lovett and J. Anderson, "History of Success and Current Context in Problem Solving," *Cognitive Psychology* Volume 31, Issue 2 (1996): 169.

[200]M. Bilalic, P. McLeod, and F. Gobet, "Inflexibility of Experts, Reality or Myth," *Cognitive Psychology* Volume 56, Issue 2 (2008): 88.

[201]S. M. Smith and S.E. Blackenship, "Incubation and the Persistence of Fixation in Problem Solving". *American Journal of Psychology* Volume 104, Issue 1 (1991): 6.

[202]Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 584.

[203]J. Canas, J. Quesada, A. Antoli, and I. Fajardo, "Cognitive Flexibility and Adaptability to Environmental Changes in Dynamic Complex Problem Solving Tasks,"*Ergonomics* Volume 46, Issue 5 (2003): 487; Lewandowsky, Little, and Kalish, "Knowledge and Expertise," 86; Erik Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 585.

depth of knowledge and the stability of their previously successful mental models. When presented with a novel problem or outlier dat2a, experts tend to activate the same cognitive model even though the problem potentially calls for a new model or approach.[204] "As expertise develops, the number of combination and reorganization possibilities rises owing to the increasing complexity of one's cognitive models."[205] Increased availability of cognitive material should provide experts increased capability to conceptually integrate and create new and novel ideas. Increased knowledge should provide a larger "network of possible wanderings" and connections.[206] However, an expert's inability to adapt to new outlier information hampers their creative ability.[207] It appears that as expertise increases so does both mental model stability and thought and behavior inflexibility. The stability of an entrenched expert's mental model may limit their ability to combine and reorganize divergent concepts differently from their established rules and models.[208] These combined behaviors result in increased difficulty breaking existing habits and creating new ones.[209]

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[204]Richard P. Bagozzi and Utpal M. Dholakia, "How Formulating Implementation Plans and Remembering Past Actions Facilitate the Enactment of Effortful Decisions," *Journal of Behavioral Decision Making* Volume 20, Issue 4 (October 2007): 360.

[205]D. Mumford, C. Blair, L. Dailey, L. E. Leritz, and H.K. Osburn, "Errors in Creative Thought? Cognitive Biases in a Complex Processing Activity," *The Journal of Creative Behavior* Volume 40, Issue 75-109 (2006): 381.

[206] Erik Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 588.

[207]Ibid., 587.

[208]Devin C. Lonergan, Ginamarie M. Scott, and Michael D. Mumford, "Evaluative Aspects of Creative Thought: Effects of Appraisal and Revisions Standards," *Creativity Research Journal* Volume 16, Issue 2-3 (2004): 232; Michael D. Mumford, "Where Have We Been, Where Are We Going? Taking Stock in Creativity Research," *Creativity Research Journal* Volume15, Issue 2 (2003): 111.

[209]Erik Dane, "Reconsidering the Trade-Off between Expertise and flexibility," 585.

Section Summary: Increase Diversity and Limit Early Evaluation

Creativity and understanding can be enhanced or inhibited in many ways. The key attributes to enhancing creativity have been identified as life experience diversity and cognitive diversity, which serve as the primary precursors of creativity. Additionally, avoiding early evaluation during problem solving, oppositional cognitive blending, diffused and down-regulated attention, and positive moods have all been associated with enhanced creativity. In contrast, limited exposure to new and novel ideas or new problem solving examples, depth of knowledge, age, experience and cognitive entrenchment are associated with analytical and critical problem solving as well as the dominate means of creativity inhibition.

Conclusion and Further Thoughts

Creativity is fundamental to understanding complex and ill-structured problems. Creativity generates new possibilities to inject into the understanding process, moving it beyond critical thinking alone. Creativity is enhanced by both life experience diversity and cognitive diversity, as well as by delayed evaluation during problem solving, or can be inhibited by a lack of diversity and cognitive entrenchment. Creativity is dependent on associating a wide array of novel or divergent experiences to form a new, appropriate idea. However, closed institutions such as the U.S. Army have limited pools of divergence from which to draw, relying instead on the commander's experience, which may provide exposure to many ideas over a lengthy career, but the ability to associate them into new creative ideas may be inhibited over the same time period

The process of creativity is embedded in the "conceptual and creative side" of the operations process. During understanding, after problem identification, unassociated divergent thoughts, provided by life experience diversity and cognitive diversity, which provide a wide array of cognitive material to support oppositional blending, are conceptually integrated during moments of liminality and positive mood. Periods of incubation and diffused attention follow, resulting in creative insight, if preexisting cognitive models resulting from cognitive entrenchment, age, and expertise do not inhibit the process. If this insight passes through an appropriateness filter and emerges into consciousness, it can be further synthesized with other abstract thoughts to form a vision and facilitate creative problem identification and problem solutions

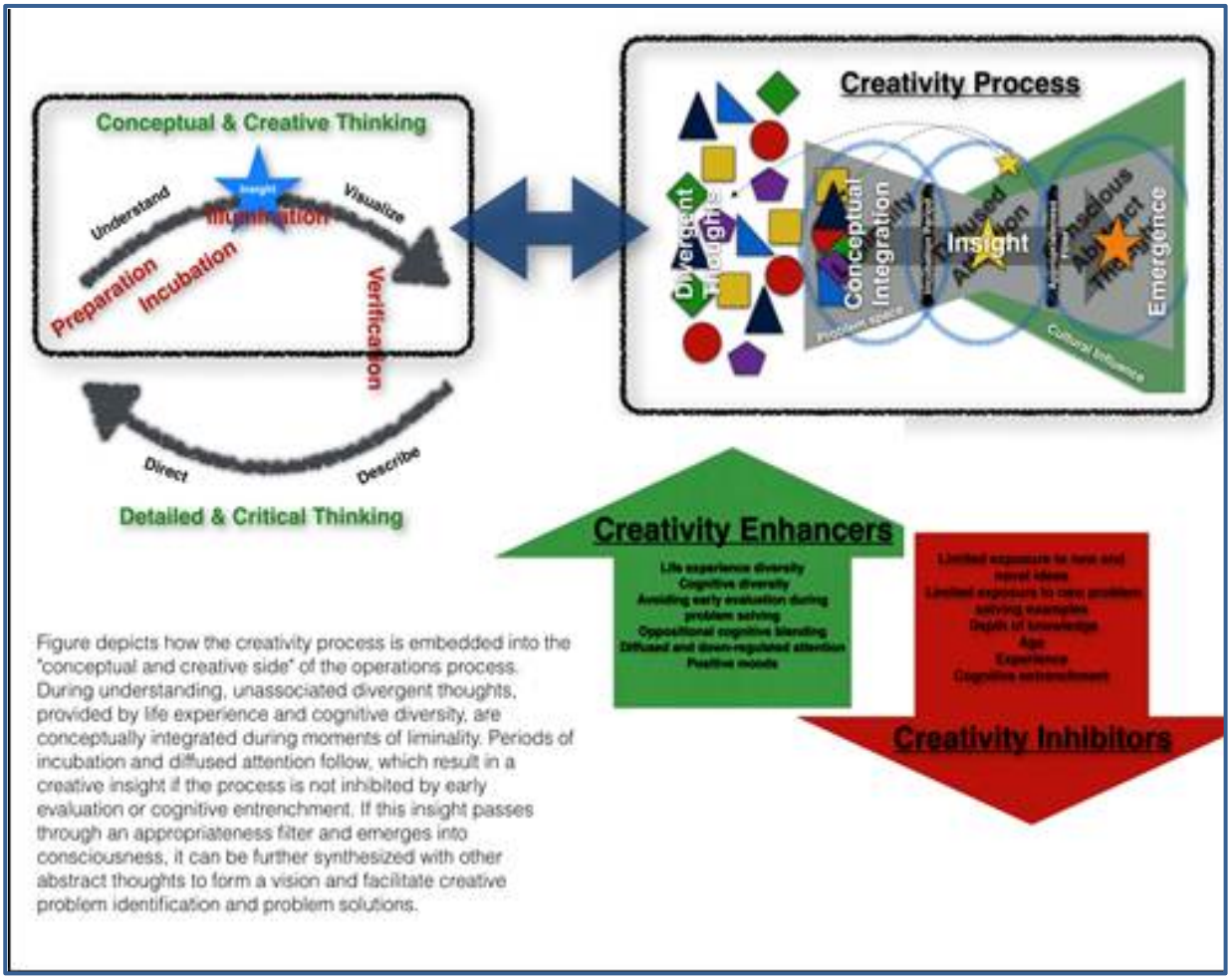

Figure 6: Synthesis[210]

The principal logic of this paper was based on the argument that creativity, the generation of new ideas that are both novel and appropriate, is essential to understanding complex problems, and can be enhanced by both life experience diversity and cognitive diversity, as well as by delayed evaluation during problem solving, or can be inhibited by a lack of diversity and cognitive entrenchment. In essence, creativity is dependent on associating a wide array of novel

[210]T. Kurtz, Figure depicts how the creativity process is embedded into the "conceptual and creative side" of the operations process. During understanding, unassociated divergent thoughts, provided by life experience and cognitive diversity, are conceptually integrated during moments of liminality. Periods of incubation and diffused attention follow, which result in a creative insight. If this insight passes through an appropriateness filter and emerges into consciousness, it can be further synthesized with other abstract thoughts to form a vision and facilitate creative problem identification and problem solutions.

or divergent experiences to form a new, appropriate, idea; however, closed institutions such as the U.S. Army have limited pools of divergence from which to draw, relying instead on the commander's experience, which may provide exposure to many ideas over a lengthy career, but the ability to associate them into new creative ideas may be inhibited over the same time period. Recall, the same skills that allow a commander to be successful while solving routine or simple problems may actually inhibit his ability to solve complex or ill-structured problems. Professional success is usually associated with years of specialized narrowly focused experience, specialized and focused education, and entrenched intuitions, that when combined, allow for rapid problem solution identification. However, complex and ill-defined problems requiring creative solutions may need additional time, multiple diverse inputs, as well as suspension of early solution finding before a problem solution emerges. Creative problem solving, essentially the polar opposite of critical problem solving, can be a very uncomfortable process for a successful professional accustomed to rapid problem solution identification. The importance of enhancing creativity is to balance the concrete specialized experiences, education, and intuitions developed in successful leaders with more abstract and diverse creativity.

Further Thoughts: How to Enhance Creativity and Understanding Across the U.S. Army

How can creativity be fostered and increased across the entire U.S. Army? Although individual commanders and operational planners may already be engaged in exceptional creative efforts, their methods and experiences are not institutionalized and propagated throughout the force. Enacting changes to doctrine, training, and leadership and education could provide the means to enhance creativity throughout the U.S. Army.

In current doctrine, the Army Design Process, as outlined in FM 5-0, describes an attempt to institutionalize creativity in the U.S. Army. As excellent as it may be the process falls flat, and often becomes time and product driven, primarily focused on the deliverables such as the frames

and narratives, not on creative understanding, problem identification, and solutions. A recommendation is to incorporate into doctrine how design, or any other creative process, may not yield immediate results, or may not yield results at all. However, doctrine should also stress the mere exercise of thinking about what you know, or do not know, or what you understand or do not understand is not a futile exercise. The ability to think in an unstructured environment, with down-regulated attention, free of deliverables has the potential to produce great depths of knowledge and understanding. The "product" may not be timely or customary; however, it may offer new creative perspectives and possibilities for understand and potentially acting in ill-structured problems.

Iterative training is crucial to developing functional staffs. However, the manner in which the training is conducted is potentially more important than the frequency. During the deliberate planning process, mission analysis is a key step to understand your organization, your enemy, and the environment in which both are contained. Too often however, mission analysis becomes a process of filling in quad charts and other constructs in a time-constrained rush. Nothing new is produced, no creative understanding is gained, and no creative abstract synthesis is generated to promote better and deeper understanding. As a recommendation, mission analysis training should instead focus on the quality of the output, moving beyond collections of lists and charts and other constructs, which may inhibit the free flow of ideas and knowledge among the participants. Mission analysis should be able to compile a wide array of divergent ideas collected throughout the staff to present a new, creative understanding of how the system works and what provides its energy, but this takes time and patience. One of the greatest inhibitors to mission analysis currently may be its prescriptive format. Instead, soldiers could be trained without a mission analysis format to break the reliance on what chart or construct to use, rather instead, train them how to integrate diverse data points into a new idea that provides insight for the commander.

All things that happen in the U.S. Army are ultimately the result of leadership. Senior leaders set the conditions and establish the priorities that either enhance or inhibit creativity. If a

command wants to enhance creativity there are basic questions it needs to answer. Are junior leaders encouraged to take risk, venturing outside the norm, and possibly identifying new problem solving examples? Does the command value input from divergent sources, especially non-military sources that often see and understand events and issues very differently? Is the command willing to allow and promote opportunities to gain life experience and cognitive diversity through broadening experiences such as exposure to art, film, and architecture or other fields that routinely create new products and ideas? Is the atmosphere positive? All of these creativity enhancers depend on senior leader promotion and encouragement.

Education is a primary source for the development of creativity enhancers. However, if the education fails to provide a wide array of new perspectives, experiences, and thinking, it may only serve to strengthen the effects of creativity inhibitors. Education outside the U.S. Army and DoD education system could provide boundless new perspectives and insights, which could be reintegrated back into the U.S. Army in the form of new problem solving techniques, or simply new ways to think about things. Although an opportunity currently exists for a few select officers to participate in civilian education, a recommend approach is that all field grade officer's sabbatical for a period of 18 to 24 months to attain an advanced degree from a civilian institution. The same could be done for work with industry opportunities. The essential point is to expose an officer with eight to twelve years of experience to a vast new set of divergent and creative experiences to bring back to the U.S. Army to make it a better institution.

These are just a few recommendations that could assist fostering and enhancing creativity in the U.S. Army. If, as most service leaders anticipate, the U.S. Army will continue to be faced with ever changing, complex, ill-structured problems, one of the greatest assets it can offer is the ability to think creatively and develop creative understanding.

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